# M.Sc. Artificial Intelligence and Machine Learning (PO 2023)

**Module Handbook**
FB 20 - Department of Computer Science
Date: 01.09.2023

TECHNISCHE UNIVERSITÄT DARMSTADT

Informatik

**INFORMATION:**
This translation is not an official document. It is a service for our international students and prospective students.

The English translation is for information purpose only.
The legally binding document is the German version.

Module Handbook: M.Sc. Artificial Intelligence and Machine Learning (PO 2023)

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FB 20 - Department of Computer Science

# Contents

# 1 Elective Areas and Studium Generale

## 1.1 Elective Areas

### 1.1.1 Technical Examinations from the Elective Areas of the M.Sc. Artificial Intelligence and Machine Learning

#### 1.1.1.1 Foundations of Artificial Intelligence

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Causality for Artificial Intelligence and Machine Learning | | | | | | |
| **Module nr.**<br>20-00-1189 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. phil. Iryna Gurevych | | | |
| 1 | **Courses of this module** | | | | | |
| | **Course nr.** | **Course name** | **Workload (CP)** | **Teaching form** | **HPW** | |
| | 20-00-1189-vl | Causality for Artificial Intelligence and Machine Learning | 0 | Lecture | 2 | |
| 2 | **Teaching content**<br>The lecture is structured to provide a comprehensive overview of the many facets of discussing causal modelling assumptions, formulating the causal query of interest, discerning correlations from causation and inferring the causal structure and parameterization of interest. Respectively, explored topics include:<br>• Introduction and motivation to Pearlian causality and causality for AI & ML<br>• From statistical to causal learning<br>• The Pearl Causal Hierarchy of observations, interventions and counterfactuals<br>• Discovering causal relationships<br>• Structural Causal Models (SCM)<br>• Learning neurally parameterized SCM<br>• Common assumptions in the causal inference literature<br>• Theoretical underpinnings of causality<br>• Benchmarks for causal inference<br>• Existing areas of research within the intersection of causality and machine learning<br>• Open-ended research questions and applications | | | | | |
| 3 | **Learning objectives** | | | | | |

| | |
|---|---|
| | Understanding causal interactions is central to human cognition and unlocking similar capabilities in machines is a central new quest in the study of artificial intelligence and machine learning. The Pearlian theory of causality poses as a key player in the new dawn of intelligent machines through the rigorous formalization of ideas such as interventions, counterfactuals and structural mechanisms.<br><br>Upon successful completion of the module, students will have learned to go beyond the realm of pure statistics and correlations in the data domain, that ultimately pose an insurmountable wall to modern techniques like deep learning, and start embracing approaches that make us of modelling assumptions in order to reason about causal quantities. In addition to a comprehensive overview of the fundamentals of Pearlian causality and cutting-edge approaches at the intersection of causality with AI & ML, students will have expanded their knowledge with techniques for causal inference spanning across the hierarchy of causal reasoning to improve sample efficiency, robustness and generalization capabilities of existing models. |
| **4** | **Prerequisite for participation**<br>Recommended:<br><br>Basic mathematical knowledge on probability theory and statistics is required as covered in the course "Mathematics III for Computer Science".<br>Basic machine learning knowledge from at least one or more of the following courses is required: "Statistical Machine Learning", "Introduction to Artificial Intelligence", "Probabilistic Graphical Models", "Deep Learning", or one of the several offered Praktika.<br>Basic knowledge on graphical models is recommended as covered in the course "Probabilistic Graphical Models". |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-1189-vl] (Technical examination, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.<br>Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests). |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%). |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1189-vl] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Deep Learning: Architectures & Methods

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1034 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1034-iv | Deep Learning: Architectures & Methods | 0 | Integrated course | 4 |

**2 Teaching content**

- Review of machine learning background
- Deep Feedforward Networks
- Regularization for Deep Learning
- Optimization for Training Deep Models
- Convolutional Networks
- Sequence Modeling: Recurrent and Recursive Nets
- Linear Factor Models
- Autoencoders
- Representation Learning
- Structured Probabilistic Models for Deep Learning
- Monte Carlo Methods
- Approximate Inference
- Deep Generative Models
- Deep Reinforcement Learning
- Deep Learning in Vision
- Deep Learning in NLP

**3 Learning objectives**

This course provides students with the required advanced background on machine learning the knowledge to independently carry out research projects on the hot topic of deep learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of deep learning algorithms and the architecture of deep networks.

**4 Prerequisite for participation**

20-00-0358-iv Statistical Machine Learning
20-00-0052-iv Data Mining and Machine Learning

**5 Form of examination**

Course related exam:

- [20-00-1034-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1034-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Introduction to Artificial Intelligence

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1058 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1058-iv | Introduction to Artificial Intelligence | 0 | Integrated course | 3 |

**2 Teaching content**

Artificial Intelligence (AI) is concerned with algorithms for solving problems, whose solution is generally assumed to require intelligence. While research in the early days was oriented on results about human thinking, the field has since developed towards solutions that try to exploit the strengths of the computer. In the course of this lecture we will give a brief survey over key topics of this core discipline of computer science, with a particular focus on the topics search, planning, learning, and reasoning. Historical and philosophical foundations will also be considered.

- Foundations
- Introduction, History of AI (RN chapter 1)
- Intelligent Agents (RN chapter 2)
- Search
- Uninformed Search (RN chapters 3.1 - 3.4)
- Heuristic Search (RN chapters 3.5, 3.6)
- Local Search (RN chapter 4)
- Constraint Satisfaction Problems (RN chapter 6)
- Games: Adversarial Search (RN chapter 5)
- Planning
- Planning in State Space (RN chapter 10)
- Planning in Plan Space (RN chapter 11)
- Decisions under Uncertainty
- Uncertainty and Probabilities (RN chapter 13)
- Bayesian Networks (RN chapter 14)
- Decision Making (RN chapter 16)
- Machine Learning
- Neural Networks (RN chapters 18.1,18.2,18.7)
- Reinforcement Learning (RN chapter 21)
- Philosophical Foundations

**3 Learning objectives**

After a successful completion of this module, students are in a position to

- understand and explain fundemental techniques of artificial intelligence
- participate in a discussion about the possibility of an artificial intelligence with well-founded arguments
- critically judge new developments in this area

**4 Prerequisite for participation**

**5 Form of examination**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1058-iv] (Technical examination, Oral/written examination, Default RS)<br>Written Exam (90 min.) |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1058-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>M.Sc. Autonome Systeme und Robotik<br>M.Sc. Artificial Intelligence and Machine Learning<br><br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Probabilistic Graphical Models

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0449 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Ph. D. Stefan Roth |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0449-iv | Probabilistic Graphical Models | 0 | Integrated course | 4 |

**2 Teaching content**
- Refresher of probability & Bayesian decision theory
- Directed and undirected models and their properties
- Inference in tree graphs
- Approximate inference in general graphs: Message passing and mean field
- Learning of directed and undirected models
- Sampling methods for learning and inference
- Modeling in example applications, including topic models
- Deep networks
- Semi-supervised learning

**3 Learning objectives**
After successfully attending the course, students have developed an in-depth understanding of probabilistic graphical models. They describe and analyze properties of graphical models, and formulate suitable models for concrete estimation and learning tasks. They understand inference algorithms, judge their suitability and apply them to graphical models in relevant applications. Moreover, they determine which learning algorithms are suitable to estimate the model parameters from example data, and apply these.

**4 Prerequisite for participation**
Recommended: Participation in “Statistisches Maschinelles Lernen”.

**5 Form of examination**
Course related exam:
- [20-00-0449-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0449-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Literature recommendations will be updated regularly, an example might be:<br>- D. Barber: “Bayesian Reasoning and Machine Learning”, Cambridge University Press 2012<br>- D. Koller, N. Friedman: “Probabilistic Graphical Models: Principles and Techniques”, MIT Press 2009 |
| **10** | **Comment** |

**Module name**
Reinforcement Learning: From Foundations to Deep Approaches

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1047 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1047-iv | Reinforcement Learning: From Foundations to Deep Approaches | 0 | Integrated course | 4 |

**2 Teaching content**
- Review of machine learning background
- Black box Reinforcement Learning
- Modeling as bandit, Markov Decision Processes and Partially Observable Markov Decision Processes
- Optimal control
- System identification
- Learning value functions
- Policy search
- Deep value functions methods
- Deep policy search methods
- Exploration vs exploitation
- Hierarchical reinforcement learning
- Intrinsic motivation

**3 Learning objectives**
This course provides students with the required basic background on machine learning the knowledge to independently carry out research projects on the hot topic of reinforcement learning, e.g. within the scope of a Bachelor's or Master's thesis. In particular, this class aims at providing the students with fundamental understanding of reinforcement learning algorithms and the application within deep learning.

**4 Prerequisite for participation**
Good programming in Python.
Lecture Statistical Machine Learning is helpful but not mandatory.

**5 Form of examination**
Course related exam:
- [20-00-1047-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1047-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Statistical Relational Artificial Intelligence: Logic, Probability, and Computation

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1011 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1011-iv | Statistical Relational Artificial Intelligence: Logic, Probability, and Computation | 0 | Integrated course | 4 |

**2 Teaching content**
+ Logic programming
+ Inductive logic programming, i.e., learning logical programs from data
+ Probabilistic graphical models: Inference and Learning
+ Statistical relational models such as ProbLog and Markov logic networks
+ Inference within statistical relational models
+ Learning statistical relational models from data
+ Relational linear and quadratic programs

**3 Learning objectives**
The lecture provides a systematic introduction to the foundations and methods of statistical relational learning and AI: the study and design of intelligent agents that act in worlds composed of individuals (objects, things), where there can be complex relations among the individuals, where the agents can be uncertain about what properties individuals have, what relations are true, what individuals exist, whether different terms denote the same individual, and the dynamics of the world. After the successful completion of the course, students understand the basic concepts and methods of statistical relational AI. They understand the basic challenges posed by relational domains and know the current state of the art to meet tem. They are able to apply the acquired toolbox to novel problems.

**4 Prerequisite for participation**
The successful completion of “Statistical Machine Learning” and of “Probabilistic Graphical Models” is recommended but not required.

**5 Form of examination**
Course related exam:
- [20-00-1011-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1011-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

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|---|---|
| | Pointers to literature will be updated regularly and include:<br><br>Luc De Raedt, Kristian Kersting, Sriraam Natarajan, David Poole (2016): Statistical Relational Artificial Intelligence: Logic, Probability, and Computation. Synthesis Lectures on Artificial Intelligence and Machine Learning, Morgan & Claypool Publishers, ISBN: 9781627058414. |
| **10** | **Comment** |

**Module name**
Statistical Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0358 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Kristian Kersting |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0358-iv | Statistical Machine Learning | 0 | Integrated course | 4 |

**2 Teaching content**
- Statistical Methods for Machine Learning
- Refreshers on Statistics, Optimization and Linear Algebra
- Bayes Decision Theory
- Probability Density Estimation
- Non-Parametric Models
- Mixture Models and EM-Algorithms
- Linear Models for Classification and Regression
- Statistical Learning Theory
- Kernel Methods for Classification and Regression

**3 Learning objectives**
The lecture gives a systematic introduction to statistical methods for machine learning. Upon successful completion of this lecture, students will understand the most important methods and approaches of statistical machine learning. They can apply machine learning to solve various new problems.

**4 Prerequisite for participation**

**5 Form of examination**
Course related exam:
- [20-00-0358-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0358-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

| | |
|---|---|
| **9** | **References**<br>1. C.M. Bishop, Pattern Recognition and Machine Learning (2006), Springer<br>2. K.P. Murphy, Machine Learning: a Probabilistic Perspective (expected 2012), MIT Press<br>3. D. Barber, Bayesian Reasoning and Machine Learning (2012), Cambridge University Press<br>4. T. Hastie, R. Tibshirani, and J. Friedman (2003), The Elements of Statistical Learning, Springer Verlag<br>5. D. MacKay, Information Theory, Inference, and Learning Algorithms (2003), Cambridge University Press<br>6. R.O. Duda, P.E. Hart, and D.G. Stork, Pattern Classification (2nd ed. 2001), Willey-Interscience<br>7. T.M. Mitchell, Machine Learning (1997), McGraw-Hill |
| **10** | **Comment** |

### 1.1.1.2 AI Models and Methods

| **Module name**<br>Data Mining and Machine Learning | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-0052 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0052-iv | Data Mining and Machine Learning | 0 | Integrated course | 4 |

**2 Teaching content**

With the rapid development of information technology bigger and bigger amounts of data are available. These often contain implicit knowledge, which, if it were known, could have significant commercial or scientific value. Data Mining is a research area that is concerned with the search for potentially useful knowledge in large data sets, and machine learning is one of the key techniques in this area.

This course offers an introduction into the area of machine learning from the angle of data mining. Different techniques from various paradigms of machine learning will be introduced with exemplary applications. To operationalize this knowledge, a practical part of the course is concerned with the use of data mining tools in applications.

- Introduction (Foundation, Learning problems, Concepts, Examples, Representation)
- Rule Learning
  - Learning of indivicual rules (generalization vs. specialization, structured hypothesis spaces, version spaces)
  - Learning of rule sets (covering strategy, evaluation measures for rules, pruning, multi-class problems)
- Evaluation and cost-sensitive Learning (Accuracy, X-Val, ROC Curves, Cost-Sensitive Learning)
- Instance-Based Learning (kNN, IBL, NEAR, RISE)
- Decision Tree Learning (ID3, C4.5, etc.)
- Ensemble Methods (Bias/Variance, Bagging, Randomization, Boosting, Stacking, ECOCs)
- Pre-Processing (Feature Subset Selection, Discretization, Sampling, Data Cleaning)
- Clustering and Learning of Association Rules (Apriori)"

**3 Learning objectives**

After a successful completion of this module, students are in a position to
- understand and explain fundemental techniques of data mining and machine learning
- apply practical data mining systems and understand their strengths and limitations
- critically judge new developments in this area

**4 Prerequisite for participation**

**5 Form of examination**

Course related exam:
- [20-00-0052-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

| | |
|---|---|
| 6 | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| 7 | **Grading**<br>Course related exam:<br>• [20-00-0052-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| 8 | **Usability of the module**<br>B. Sc. Informatik<br>M. Sc. Informatik<br>M. Sc. Computer Science<br>M. Sc. Autonome Systeme und Robotik<br>M. Sc. Artificial Intelligence and Machine Learning<br>M. Sc. IT Sicherheit<br><br>May be used in other degree programs. |
| 9 | **References**<br>- Mitchell: Machine Learning, McGraw-Hill, 1997<br>- Ian H. Witten and Eibe Frank: Data Mining: Practical Machine Learning Tools and Techniques with Java Implementations, Morgan-Kaufmann, 1999 |
| 10 | **Comment** |

**Module name**
Deep Learning for Medical Imaging

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1014 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr.-Ing. Michael Gösele |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1014-iv | Deep Learning for Medical Imaging | 0 | Integrated course | 3 |

**2 Teaching content**
Formulating Medical Image Segmentation, Computer Aided Diagnosis and Surgical Planning as Machine Learning Problems, Deep Learning for Medical Image Segmentation, Deep Learning for Computer Aided Diagnosis, Surgical Planning from pre-surgical images using Deep Learning, Tool presence detection and localization from endoscopic videos using Deep learning, Adversarial Examples for Medical Imaging, Generative Adversarial Networks for Medical Imaging.

**3 Learning objectives**
After successful completion of the course, students should be able to understand all components of formulating a Medical Image Analysis problem as a Machine Learning problem. They should also be able to make informed decision of choosing a general purpose deep learning paradigm for given medical image analysis problem.

**4 Prerequisite for participation**
- Programming skills
- Understanding of Algorithmic design
- Linear Algebra
- Image Processing / Computer Vision I
- Statistical Machine Learning

**5 Form of examination**
Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1014-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Deep Learning for Natural Language Processing

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0947 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0947-iv | Deep Learning for Natural Language Processing | 0 | Integrated course | 4 |

**2 Teaching content**
The lecture provides an introduction to the foundational concepts of deep learning and their application to problems in the area of natural language processing (NLP)
Main content:
- foundations of deep learning (e.g. feed-forward networks, hidden layers, backpropagation, activation functions, loss functions)
- word embeddings: theory, different approaches and models, application as features for machine learning
- different architectures of neuronal networks (e.g. recurrent NN, recursive NN, convolutional NN) and their application for groups of NLP problems such as document classification (e.g. spam detection), sequence labeling (e.g. POS-tagging, Named Entity Recognition) and more complex structure prediction (e.g. Chunking, Parsing, Semantic Role Labeling)

**3 Learning objectives**
After completion of the lecture, the students are able to
- explain the basic concepts of neural networks and deep learning.
- explain the concept of word embeddings, train word embeddings and use them for solving NLP problems.
- understand and describe neural network architectures that are used to tackle classical NLP problems such as classification, sequence prediction, structure prediction.
- implement neural networks for NLP problems using existing libraries in Python.

**4 Prerequisite for participation**
Basic knowledge of mathematics and programming

**5 Form of examination**
Course related exam:
- [20-00-0947-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0947-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

**Module name**
Information Theory I: Fundaments

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 18-kp-1010 | 6 CP | 180 h | 120 h | 1 Term | Winter term |

| Language | Module owner |
|---|---|
| English | Prof. Dr. techn. Heinz Köppl |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 18-kp-1010-vl | Information Theory I: Fundaments | 0 | Lecture | 3 |
| 18-kp-1010-ue | Information Theory I: Fundaments | 0 | Practice | 1 |

**2 Teaching content**
This lecture course introduces the fundamentals of information theory, network information theory and coding theory.
Outline:
information, uncertainty, entropy, mutual information, capacity, differential entropy, typical sequences, Gaussian channels, basics of source and channel coding, linear block codes, Shannon's source coding theorem, Shannon's channel coding theorem, capacity of Gaussian channels, capacity of bandlimited channels, Shannon's bound, bandwidth efficiency, capacity of multiple parallel channels and waterfilling, Gaussian vector channel, Multiple Access Channel, Broadcast Channel, rate region.

**3 Learning objectives**
Upon completion of the module, students will have an understanding of the fundamentals of classic information theory.

**4 Prerequisite for participation**
Recommended: Basic knowledge of probability theory

**5 Form of examination**
Module exam:
- Module exam (Technical examination, Examination, Duration: 120 Min., Default RS)

**6 Prerequisite for the award of credit points**
Passing the final module examination

**7 Grading**
Module exam:
- Module exam (Technical examination, Examination, Weighting: 100 %)

**8 Usability of the module**
BSc ETiT, BSc iST, MSc iCE, BSc Wi-ETiT, BSc/MSc CE

**9 References**


1. T.M. Cover and J.A. Thomas, Elements of Information Theory, Wiley & Sons, 1991.
2. R. W. Yeung, Information Theory and Network Coding, Springer, 2008.
3. Abbas El Gamal and Young-Han Kim, Network Information Theory, Cambrige, 2011.


**10 Comment**

**Module name**
Continual Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1135 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. Arjan Kuijper |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1135-vl | Continual Machine Learning | 0 | Lecture | 2 |

**2 Teaching content**

The course is structured to provide a comprehensive overview of the many facets involved in design, training, and evaluation of continually evolving systems. Respectively explored topics include:

- Introduction and motivation to learning continually
- From domain adaptation and transfer to continual learning
- Alleviating catastrophic forgetting: methodologies and examples
- Active learning: selecting future data
- Modular and dynamic architectures
- Curriculum learning
- Closed and open world assumptions
- Continual learning benchmarks and metrics
- Learning to learn: a meta-learning perspective
- Software developments for continual learning
- Open-ended research questions and applications

**3 Learning objectives**

Machine learning studies the design of models and training algorithms in order to learn how to solve tasks from data. Whereas historically machine learning has concentrated primarily on static predefined training datasets and respective test scenarios, recent advances also take into account the fact that the world is constantly evolving. Upon successful completion of the module, students will have learned to go beyond the train-validate-test phase and embrace modern approaches to machines that can learn continually. In addition to a comprehensive overview of the breath of factors to consider in continual learning, students will have expanded their knowledge with techniques that span mitigation of forgetting across multiple tasks, selection of new data in continuous training, dynamic model architectures, and robustness with respect to unexpected data inputs.

**4 Prerequisite for participation**

Basic machine learning knowledge from at least one of the following courses is recommended: statistical machine learning, introduction to artificial intelligence, probabilistic graphical models, deep learning, or one of the several offered Praktika.

**5 Form of examination**

Course related exam:

- [20-00-1135-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1135-vl] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Robot Learning | | | | | |
| **Module nr.**<br>20-00-0629 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner** | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0629-vl | Robot Learning | 0 | Lecture | 4 |

**2 Teaching content**

- Foundations from robotics and machine learning for robot learning
- Learning of forward models
- Representation of a policy, hierarchical abstraction wiith movement primitives
- Imitation learning
- Optimal control with learned forward models
- Reinforcement learning and policy search
- Inverse reinforcement learning

**3 Learning objectives**

Upon successful completion of this course, students are able to understand the relevant foundations of machine learning and robotics. They will be able to use machine learning approaches to empower robots to learn new tasks. They will understand the foundations of optimal decision making and reinforcement learning and can apply reinforcement learning algorithms to let a robot learn from interaction with its environment. Students will understand the difference between Imitation Learning, Reinforcement Learning, Policy Search and Inverse Reinforcement Learning and can apply each of this approaches in the appropriate scenario.

**4 Prerequisite for participation**

Good programming in Matlab
Lecture Machine Learning 1 - Statistical Approaches is helpful but not mandatory.

**5 Form of examination**

Course related exam:

- [20-00-0629-vl] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0629-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Deisenroth, M. P.; Neumann, G.; Peters, J. (2013). A Survey on Policy Search for Robotics, Foundations and Trends in Robotics<br>Kober, J; Bagnell, D.; Peters, J. (2013). Reinforcement Learning in Robotics: A Survey, International Journal of Robotics Research<br>C.M. Bishop, Pattern Recognition and Machine Learning (2006),<br>R. Sutton, A. Barto. Reinforcement Learning - an Introduction<br>Nguyen-Tuong, D.; Peters, J. (2011). Model Learning in Robotics: a Survey |
| **10** | **Comment** |

**Module name**
Model Checking

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1115 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr.-Ing. Ermira Mezini |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1115-iv | Model Checking | 0 | Lecture | 4 |

**2 Teaching content**

- Temporal logics
  - Linear temporal logic (LTL), Computation tree logic (CTL) und CTL*: syntax, sematics, complexity
- Model checking LTL, CTL und CTL*
- Partial order reduction
- Timed automata

**3 Learning objectives**

In this module students acquire

- Knowledge of the theoretical foundations of LTL, CTL and CTL*
- Ability to choose a suitable logic for specification and model checking by taking into consideration the system to be modelled and the kind of properties to be checked
- Knowledge about different model checking techniques like model checking using Büchi automata, partial order reduction and more
- Knowledge about characteristics and limitations of model checking
- Knowledge in model checking of timed automata
- Ability to use model checker tools

**4 Prerequisite for participation**

Recommended is knowledge about

- propositional logic
- deduction systems
- automata theory

**5 Form of examination**

Course related exam:

- [20-00-1115-iv] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1115-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Optimization of static and dynamic systems

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0186 | 10 CP | 300 h | 210 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0186-iv | Optimization of static and dynamic systems | 0 | Integrated course | 6 |

**2 Teaching content**

optimization for static systems:
- unconstrained and constrained nonlinear optimization, optimality conditions
- numerical Newton type and SQP methods
- nonlinear least squares
- gradient free optimization methods
- practical aspects like problem formulation, approximation of derivatives, method specific parameters, assessment of a computed solution

optimization for dynamic systems:
- parameter optimization and estimation problems
- optimal control problem
- maximum principle and optimality conditions
- numerical methods for computing optimal trajectories
- optimal feedback control
- linear quadratic regulator

applications and case studies from engineering sciences and robotics

theoretical and practical assignments as well as programming tasks for deepening of knowledge and methodological skills

**3 Learning objectives**

Through successful participation students acquire fundamental knowledge and methodological skills in concepts, techniques and computational methods of optimization for static and dynamic systems and their application for optimization problems in engineering sciences.

**4 Prerequisite for participation**

grundlegende mathematische Kenntnisse und Fähigkeiten in Linearer Algebra, Analysis mehrerer Veränderlicher und Grundlagen gewöhnlicher Differentialgleichungen

**5 Form of examination**

Course related exam:
- [20-00-0186-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-0186-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

| | |
|---|---|
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>May be used in other degree programs. |
| **9** | **References**<br>- Script of Lecture<br><br>- J. Nocedal, S.J. Wright: Numerical Optimization, Springer<br>- C.T. Kelley: Iterative Methods for Optimization, SIAM Frontiers in Applied Mathematics<br>- L.M. Rios, N.V. Sahinidis: Derivative-free optimization: a review of algorithms and comparison of software implementations, Journal of Global Optimization (2013) 56:1247-1293<br>- A.E. Bryson, Y.-C. Ho: Applied Optimal Control: Optimization, Estimation and Control, CRC Press<br>- J.T. Betts: Practical Methods for Optimal Control and Estimation Using Nonlinear Programming, SIAM Advances in Design and Control |
| **10** | **Comment** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Optimization Algorithms | | | | | | |
| **Module nr.**<br>20-00-0667 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>German | | | **Module owner**<br>Prof. Dr. rer. nat. Karsten Weihe | | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0667-iv | Optimization Algorithms | 0 | Integrated course | 4 |

**2 Teaching content**

Algorithmic standard approaches to complex discrete optimization problems; for example, evolution strategies, dynamic programming, branch-and-bound, etc.

**3 Learning objectives**

In this course students acquire systematic knowledge of generic algorithmic approaches in discrete optimization and the abitiliy to tackle complex discrete optimization problems algorithmically.

**4 Prerequisite for participation**

Funktionale und objektorientierte Programmierkonzepte, Algorithmen und Datenstrukturen or similar.

**5 Form of examination**

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0667-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

Will be given in lecture.

**10 Comment**

**Module name**
Deep Generative Models

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1035 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr.-Ing. Michael Gösele |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1035-iv | Deep Generative Models | 0 | Integrated course | 4 |

**2 Teaching content**
Generative Models, Implicit and Explicit Models, Maximum Likelihood, Variational AutoEncoders, Generative Adversarial networks, Numerical Optimization for Generative models, Applications in medical Imaging

**3 Learning objectives**
After students have attended the module, they can
- Explain the structure and operation of Deep Generative Models (DGM)
- Critically scrutinize scientific publications on the topic of DGMs and thus assess them professionally
- independently construct / implement basic DTMs in a high-level programming language designed for this purpose
- Transfer the implementation and application of DTMs to different applications

**4 Prerequisite for participation**
- Python Programming
- Linear Algebra
- Image Processing/Computer Vision I
- Statistical Machine Learning

**5 Form of examination**
Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1035-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B,Sc, Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**
No textbooks as such. Online materials will be made available during the course.

**10 Comment**

### 1.1.1.3 AI Systems

| **Module name**<br>Advanced Data Management Systems | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-1039 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1039-iv | Advanced Data Management Systems | 0 | Integrated course | 4 |

**2 Teaching content**

This is an advanced course about the design of modern data management systems which has a heavy emphasis on system design and internals. Sample topics include modern hardware for data management, main memory optimisations, parallel and approximate query processing, etc.

The course expects the reading of research papers (SIGMOD, VLDB, etc.) for each class. Programming projects will implement concepts discussed in selected papers. The final grade will be based on the results of the programming projects. There will be no final exam.

**3 Learning objectives**

Upon successful completion of this course, the student should be able to:
- Understand state-of-the-art techniques for modern data management systems
- Discuss design decision of modern data management systems with emphasis on constructive improvements
- Implement advanced data management techniques and provide experimental evidence for design decisions

**4 Prerequisite for participation**

Solid Programming skills in C and C++
Scalable Data Management (20-00-1017-iv)
Information Management (20-00-0015-iv)

**5 Form of examination**

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-1039-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Analysis of Hybrid Systems

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1087 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr.-Ing. Heiko Mantel |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1087-vl | Analyse Hybrider Systeme | 0 | Lecture | 2 |

**2 Teaching content**
- Hybrid automata and important subclasses
- Reachability analysis of linear hybrid automata with flowpipes
- Differential dynamic logic
- Validity calculus for differential dynamic logic
- Modeling Principles of hybrid automata and differential dynamic logic

**3 Learning objectives**
Upon successful completion of the module, students will possess the following skills:
- Modeling Cyber-Physical Systems as hybrid automata and hybrid programs
- Specifying reachability properties and invariants of such models
- Understanding the difference between explorative and deductive verification
- Understanding basic verification algorithms for hybrid systems
- Awareness of typical modeling patterns and errors

**4 Prerequisite for participation**
Recommended: Basic knowledge of first-order logic and program verification (similar to the bachelor-level courses “Aussagenlogik und Prädikatenlogik” and “Formale Methoden im Softwareentwurf”)
Basic knowledge of ODEs (“Mathematik 3 für Informatiker” or similar)

**5 Form of examination**
Course related exam:
- [20-00-1087-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1087-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Automated Theorem Proving

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0660 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Reiner Hähnle |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0660-iv | Automated Theorem Proving | 0 | Integrated course | 4 |

**2 Teaching content**
- Theoretical foundations of calculi for automated theorem proving in first-order logic
- Correctness and completeness proofs
- Algorithms and datastructures used in first-order logic theorem provers
- Comparison of different approaches to first-order theorem proving
- Foundations of modern SAT and SMT solvers

**3 Learning objectives**
Successful participation in this course puts the students in a position where they can understand in detail how various state-of-art automated theorem proving methods work, they are able to judge their pros and cons, and they can apply them practically.

**4 Prerequisite for participation**
Highly recommeded is participation of lecture "Aussagen- und Prädiketenlogik" or similar moduls. Basic knowledge of propositional logics and first-order logics

**5 Form of examination**
Course related exam:
- [20-00-0660-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0660-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**
Robinson, Voronkov: Handbook of Automated Reasoning, 2 vols., North-Holland

**10 Comment**

**Module name**
Concepts and Technologies for Distributed Systems and Big Data Processing

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0951 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Dr.-Ing. Michael Eichberg |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0951-iv | Concepts and Technologies for Distributed Systems and Big Data Processing | 0 | Integrated course | 2 |

**2 Teaching content**

The course provides an overview of recent advances in distributed systems for Big Data processing. The course starts presenting computational models for high throughput batch processing like MapReduce. Next, we will introduce software engineering techniques for distributed systems such as REST and component-based architectures. We will then cover low latency real time stream processing and complex event processing. Finally, we will present advanced topics in distributed data-intensive systems, such as geodistribution and security.

The course focuses both on the fundamental concepts as well as on the concrete technologies and applications of the aforementioned techniques to real-world case studies.

**3 Learning objectives**

- The students are familiar with basic concepts and technologies on distributed systems and big data and are able to implement basic cloud based/distributed applications.

- The students are familiar with the fundamental computational models behind recent advances in distributed systems, such as models for batch processing of massive data amounts, stream processing and complex event processing.

- The students are familiar with selected advanced topics on big data, including security and geolocalization.

- The students know about real-world case studies that apply the concepts and the technologies presented during the course.

**4 Prerequisite for participation**

This course is targeted at master students.

**5 Form of examination**

Course related exam:

- [20-00-0951-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

| | |
|---|---|
| | Course related exam:<br>• [20-00-0951-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module** |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Scalable Data Management Systems | | | | | |
| **Module nr.**<br>20-00-1017 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1017-iv | Scalable Data Management Systems | 0 | Integrated course | 4 |

**2 Teaching content**

This course introduces the fundamental concepts and computational paradigms of scalable data management systems. The focus of this course is on the systems-oriented aspects and internals of such systems for storing, updating, querying, and analyzing large datasets.

Topics include:

Database Architectures
Parallel and Distributed Databases
Data Warehousing
MapReduce and Hadoop
Spark and its Ecosystem
Optional: NoSQL Databases, Stream Processing, Graph Databases, Scalable Machine Learning

**3 Learning objectives**

After the course the student will have a good overview of the different concepts, algorithms, and systems aspects of scalable data management. The main goal is that the students will know how to design and implement such systems including hands-on experience with state-of-the-art systems such as Spark.

**4 Prerequisite for participation**

Programming in C++ and Java
Informationsmanagement (20-00-0015-iv)

Optional:
Foundations of Distributed Systems (20-00-0998-iv)

**5 Form of examination**

Course related exam:

- [20-00-1017-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1017-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

| | |
|---|---|
| | |
| **10** | **Comment** |

### 1.1.1.4 AI Domains and Applications

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>3D Scanning & Motion Capture | | | | | |
| **Module nr.**<br>20-00-1180 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Ph. D. Jan Peters | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1180-iv | 3D Scanning & Motion Capture | 0 | Integrated course | 4 |

**2 Teaching content**

The lecture and exercises will cover 3D reconstruction from various input modalities (Webcams, RGB-D cameras (Kinect, Realsense, ...). It will start with basic concepts of what is 3D, the different representations, how to capture 3D and how the devices and sensors function. Based on this introduction, rigid and non-rigid tracking and reconstruction will be discussed. Specialized face and body tracking methods will be covered and the applications of the 3D reconstruction and tracking will be shown. In addition to the 3D surface reconstruction, techniques for appearance modelling and material estimation will be shown.

- Basic concepts of geometry (Meshes, Point Clouds, Pixels & Voxels)
- RGB and Depth Cameras (Calibration, active/passive stereo, Time of Flight (ToF), Structured Light, Laser Scanner, Lidar)
- Surface Representations (Polygonal meshes, parametric surfaces, implicit surfaces (Radial basis functions, signed distance functions, indicator function), Marching cubes)
- Overview of reconstruction methods (Structure from Motion (SfM), Multi-view Stereo (MVS), SLAM, Bundle Adjustment)
- Rigid Surface Tracking & Reconstruction (Pose alignment, ICP, online surface reconstruction pipeline (KinectFusion), scalable surface representations (VoxelHashing, OctTrees), loop closures and global optimization)
- Non-rigid Surface Tracking & Reconstruction (Surface deformation for modeling, Regularizers: ARAP, ED, etc., Non-rigid surface fitting: e.g., non-rigid ICP. Non-rigid reconstruction: DynamicFusion/VolumeDeform/KillingFusion)
- Face Tracking & Reconstruction (Keypoint detection & tracking, Parametric / Statistical Models -> BlendShapes)
- Body Tracking & Reconstruction (Skeleton Tracking and Inverse Kinematics, Marker-based motion capture)
- Material capture (Lightstage, BRDF estimation)
- Outlook DeepLearning-based tracking

**3 Learning objectives**

After successful completion of the module students have a basic understanding of 3D capturing devices and underlying principles (active vs. passive stereo, ToF etc.), modelling of geometry and conversion between different representations, principles of static reconstruction (fusion, ICP) and non-rigid reconstruction using deformation priors. They will hab a basic understanding of specialized class-specific tracking (face, body, hands) and their applications.

**4 Prerequisite for participation**

| | |
|---|---|
| | Recommended:<br>- "Algorithms and Data Structures"<br>- "Graphical Data Processing I"<br>- Knowledge of fundamentals from higher mathematics<br>- Knowledge about basics of Deep Learning<br>- Programming knowledge in C / C++ |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-1180-iv] (Technical examination, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.<br>Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests). |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%). |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1180-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Ambient Intelligence

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0390 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. Bernt Schiele |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0390-iv | Ambient Intelligence | 0 | Integrated course | 4 |

**2 Teaching content**
The course will provide an overview of a new vision for Human-Computer-Interaction (HCI) in which people are surrounded by intelligent and intuitive interfaces embedded in the everyday objects around them. In specific the course addresses the emergence of Ambient Mobility and the ubiquitous, pervasive information access, retrieval and display on mobile devices. It will focus on understanding enabling technologies and studying applications and experiments, and, to lesser extent, it will adress the sociocultural impact. Additional topics of the lecture include system architectures for distributed systems, context awareness and management, user models and their implications, sensing and interaction in smart environments. The lecture discusses recent topics and research projects in the domain of Ambient Intelligence.

**3 Learning objectives**
After successfully attending the lecture, the students will be able to describe technology trends and research results in the domain of Ambient Intelligence. The most important concepts to create smart environments - intelligent networks and objects, technologies for mobile, augmented reality, ubiquitous and pervasive information spaces, nomadic communications, real-time communication and related middle ware, embedded systems, sensor networks and wearable computing - can be discussed and classified. After completing the practical part, students will be able to plan and realize the different project phases required to develop an Ambient-Intelligence solution.

**4 Prerequisite for participation**
Master-Students
Participation in lecture “Visual Computing“ and „Multimodale Interaktion mit intelligenten Umgebungen“

**5 Form of examination**
Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0390-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Will be given according to actual topics. |
| **10** | **Comment** |

| **Module name**<br>Bioinformatics | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>10-30-0036 | **Credit points**<br>4 CP | **Workload**<br>120 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German | | | **Module owner** | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 10-01-0036-vl | Bio Informatics-Lecture | 0 | Lecture | 2 |
| 10-01-0036-se | Bio Informatics-Exercise | 0 | Practice | 2 |

**2 Teaching content**

**3 Learning objectives**

**4 Prerequisite for participation**

**5 Form of examination**

Module exam:

- Module exam (Technical examination, Oral examination, Default RS)

**6 Prerequisite for the award of credit points**

Passing the final module examination

**7 Grading**

Module exam:

- Module exam (Technical examination, Oral examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

| **Module name**<br>Capturing Reality | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-0489 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. Bernt Schiele | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0489-iv | Capturing Reality | 0 | Integrated course | 4 |

**2 Teaching content**

This course covers a broad range of techniques to capture and model our world with a focus on application in computer graphics and computer vision. This includes:
- basic tools and calibration techniques required in capturing applications
- capturing and modeling techniques for various object properties (such as geometry and reflectance)
- basic set of relevant mathematical modeling and optimization techniques
- implementation and practical application of several techniques

**3 Learning objectives**

After successful completion of the course, students are able to analyze digitization and modeling problems for objects and scenes in computer graphics and computer vision as well as the underlying techniques. They are able to develop new setups, perform experiments and evaluate the results.

**4 Prerequisite for participation**

Recommended:
Participation in lecture Graphische Datenverarbeitung I or Computer Vision I
Basic knowledge in C/C++

**5 Form of examination**

Course related exam:
- [20-00-0489-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-0489-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

| | |
|---|---|
| | Noriko Kurachi: The Magic of Computer Graphics. A K Peters/CRC Press<br>Richard Szeliski: Algorithms and Applications, Springer<br>Marcus Magnor, Oliver Grau, Olga Sorkine-Hornung, Christian Theobalt: Digital Representations of the Real World: How to Capture, Model, and Render Visual Reality<br>Wolfgang Förstner, Bernhard P. Wrobel: Photogrammetric Computer Vision - Geometry, Orientation and Reconstruction |
| **10** | **Comment** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Computer Vision I | | | | | | |
| **Module nr.**<br>20-00-0157 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. Bernt Schiele | | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0157-iv | Computer Vision | 0 | Integrated course | 4 |

**2 Teaching content**

- Basics of image formation
- Linear and (simple) nonlinear image filtering
- Foundations of multi-view geometry
- Camera calibration and pose estimation
- Foundations of 3D reconstruction
- Foundations of motion estimation from video
- Template and subspace methods for object recognition
- Object classification with bag of words
- Object detection
- Basics of image segmentation

**3 Learning objectives**

After successfully attending the course, students are familiar with the basics of computer vision. They understand fundamental techniques for the analysis of images and videos, can name their assumptions and mathematical formulations, as well as describe the resulting algorithms. They are able to implement these techniques in order to solve basic image analysis tasks on realistic imagery.

**4 Prerequisite for participation**

Particiation of lecture Visual Computing is recommended.

**5 Form of examination**

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0157-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>May be used in other degree programs. |
| **9** | **References**<br>Literature recommendations will be updated regularly, an example might be:<br>- R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011<br>- D. Forsyth, J. Ponce, ""Computer Vision – A Modern Approach"", Prentice Hall, 2002 |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Computer Vision II | | | | | |
| **Module nr.**<br>20-00-0401 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. Bernt Schiele | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0401-iv | Computer Vision II | 0 | Integrated course | 4 |

**2 Teaching content**

- Computer vision as (probabilistic) inference
- Robust estimation and modeling
- Foundations of Bayesian networks and Markov random fields
- Basic inference and learning methods in computer vision
- Image restoration
- Stereo
- Optical flow
- Bayesian tracking of (articulated) objects
- Semantic segmentation
- Current research topics

**3 Learning objectives**

After successfully attending the course, students have developed a more in-depth understanding of computer vision. They formulate image and video analysis tasks as inference problems, taking challenges of real applications into account, e.g. regarding robustness. They solve the inference problem using discrete or continuous inference algorithms, and apply these to realistic imagery. They quantitatively evaluate the application specific results.

**4 Prerequisite for participation**

Participation of lecture Visual Computing and Computer Vision I is recommended.

**5 Form of examination**

Course related exam:

- [20-00-0401-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0401-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Literature recommendations will be updated regularly, an example might be:<br>- S. Prince, “Computer Vision: Models, Learning, and Inference”, Cambridge University Press, 2012<br>- R. Szeliski, ""Computer Vision: Algorithms and Applications"", Springer 2011 |
| **10** | **Comment** |

**Module name**
Ethics in Natural Language Processing

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1061 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1061-iv | Ethics in Natural Language Processing | 0 | Integrated course | 4 |

**2 Teaching content**

Machine Learning and Natural Language technologies are integrated in more and more aspects of our life. Therefore, the decisions we make about our methods and data are closely tied up with their impact on our world and society. In this course, we present real-world, state-of-the-art applications of natural language processing and their associated ethical questions and consequences. We also discuss philosophical foundations of ethics in research.

Core topics of this course:

- Philosophical foundations: what is ethics, history, medical and psychological experiments, ethical decision making.
- Misrepresentation and bias: algorithms to identify biases in models and data and adversarial approaches to debiasing.
- Privacy: algorithms for demographic inference, personality profiling, and anonymization of demographic and personal traits.
- Civility in communication: techniques to monitor trolling, hate speech, abusive language, cyberbullying, toxic comments.
- Democracy and the language of manipulation: approaches to identify propaganda and manipulation in news, to identify fake news, political framing.
- NLP for Social Good: Low-resource NLP, applications for disaster response and monitoring diseases, medical applications, psychological counseling, interfaces for accessibility.

**3 Learning objectives**

After completion of the lecture, the students are able to
- explain philosophical and practical aspects of ethics
- show the limits and limitations of machine learning models
- Use techniques to identify and control bias and unfairness in models and data
- Demonstrate and quantify the impact of influencing opinions in data processing and news
- Identify hate speech and online abuse and develop countermeasures

**4 Prerequisite for participation**

Basic knowledge of algorithms, data structure and programming

**5 Form of examination**

Course related exam:
- [20-00-1061-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1061-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Foundations of Language Technology

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0546 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0546-iv | Foundations of Language Technology | 0 | Integrated course | 4 |

**2 Teaching content**

This lecture provides an introduction into the fundamental perspectives, problems, methods, and techniques of text technology and natural language processing using the example of the Python programming language.

Key topics:

- Natural language processing (NLP)
- Tokenization
- Segmentation
- Part-of-speech tagging
- Corpora
- Statistical analysis
- Machine Learning
- Categorization and classification
- Information extraction
- Introduction to Python
- Data structures
- Structured programming
- Working with files
- Usage of libraries
- NLTK library

The course is based on the Python programming language together with an open-source library called the Natural Language Toolkit (NLTK). NLTK allows explorative and problem-solving learning of theoretical concepts without the requirement of extensive programming knowledge.

**3 Learning objectives**

After attending this course, students are in a position to
- define the fundamental terminology of the language technology field,
- specify and explain the central questions and challenges of this field,
- explicate and implement simple Python programs,
- transfer the learned techniques and methods to practical application scenarios of text understanding, as well as
- critically assess their merits and limitations.

**4 Prerequisite for participation**

**5 Form of examination**

Course related exam:
- [20-00-0546-iv] (Technical examination, Oral/written examination, Default RS)

| | |
|---|---|
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-0546-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Steven Bird, Ewan Klein, Edward Loper: Natural Language Processing with Python, O'Reilly, 2009. ISBN: 978-0596516499. http://www.nltk.org/book/ |
| **10** | **Comment** |

**Module name**
Foundations of Robotics

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0735 | 10 CP | 300 h | 210 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0735-iv | Foundations of Robotics | 0 | Integrated course | 6 |

**2 Teaching content**
This course covers spatial representations and transformations, manipulator kinematics, vehicle kinematics, velocity kinematics, Jacobian matrix, robot dynamcis, robot sensors and actuators, robot control, path planning, localization and navigation of mobile robots, robot autonomy and robot development.

Theoretical and practical assignments as well as programming tasks serve for deepening of the understanding of the course topics.

**3 Learning objectives**
After successful participation, students possess the basic technical knowledge and methodological skills necessary for fundamental investigations and engineering developments in robotics in the fields of modeling, kinematics, dynamics, control, path planning, navigation, perception and autonomy of robots.

**4 Prerequisite for participation**
Recommended: basic mathematical knowledge and skills in linear algebra, multi-variable analysis and fundamentals of ordinary differential equations

**5 Form of examination**
Course related exam:
- [20-00-0735-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0735-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

| | |
|---|---|
| **10** | **Comment** |

**Module name**
Intelligent Robotic Manipulation: Advanced topics in Robot Perception, Planning and Control

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1181 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1181-iv | Intelligent Robotic Manipulation: Advanced topics in Robot Perception, Planning and Control | 0 | Integrated course | 4 |

**2 Teaching content**

This course introduces fundamental algorithmic approaches for creating robot systems that can autonomously manipulate physical objects in unstructured environments such as homes. We will cover basic principles for endowing autonomous robots with planning, perception, and decision-making capabilities, i.e., topics include perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), as well as dynamics and control for adaptive and reactive manipulation.

Tentative list of topics:

- Topology in robotics and rigid body motions
- Refresher on forward, inverse kinematics and dynamics
- Differential kinematics and optimization
- Geometric perception and object pose detection
- Object pose estimation and tracking and multi-sensor fusion
- Grasp generation and grasp evaluation
- Trajectory Optimization
- Search and Sampling-based motion planning
- Force control
- Visuomotor policies and intuitive physics
- Task and motion planning and belief-space planning

Practical exercises will guide understanding fundamental mathematical and algorithmic principles for enabling robotic manipulators to perceive their environment, estimate the current state of the robot itself and the robots or humans in their surroundings, and create a strategy for executing various tasks that involve autonomously manipulating objects in cluttered scenes.

**3 Learning objectives**

After completeing the module students will have learned the theoretical, algorithmic, and implementation aspects of main techniques for autonomous and intelligent robotic manipulation, in particular modeling & controls, motion planning, perception, estimation, state machines, and decision making.

With this class, the student will:

- have gained a fundamental knowledge of the “intelligence and autonomy stack” behind autonomous robots in general.
- be able to apply such knowledge in applications and research work.
- devise novel methods and algorithms for intelligent robotic manipulation.

**4 Prerequisite for participation**

| | |
|---|---|
| | Recommended:<br>The students should have a fundamental knowledge of robotics and linear algebra. Furthermore, Fundamentals of Robotics (20-00-0735-iv Grundlagen der Robotik) is recommended. Experience in Robot Learning (20-00-0629-vl Lernende Roboter) is also a plus.<br><br>Combining the course with the seminar and project lab will equip the students with a greater understanding and in-depth knowledge of the necessary components and principles to enable robotic autonomous manipulation. |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-1181-iv] (Technical examination, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.<br>Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests). |
| **6** | **Prerequisite for the award of credit points**<br>Pass Exam (100%). |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1181-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Learning and Educational Technologies

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0773 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. rer. nat. Eberhard Mühlhäuser |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0773-iv | Learning and Educational Technologies | 0 | Integrated course | 4 |

**2 Teaching content**
Digital applications and the Internet are changing the way we learn. If digital teaching and learning applications are designed appropriately, they offer a wide range of possibilities. The module aims to impart basic knowledge about the most important aspects of system design and about technologies needed for modern, web-based and mobile learning applications. Important theoretical foundations for the design of learning applications are learning theories. Therefore, learning theories are briefly discussed in the context of this module. The focus of the module is on adaptive learning applications. Different methods for the realization of adaptive learning applications will be presented. Frequently, Natural Language Processing and Artificial Intelligence methods are used for this purpose. In this context, current research work is considered. The module also focuses on the design of learning applications for individual and cooperative learning in various fields of application (e.g. school, university, vocational education and lifelong learning). Examples from current research projects as well as teaching/learning practice are presented. In addition, methods for the evaluation of learning applications are considered.

**3 Learning objectives**
After completion of the module, students will be able to analyze and design applications for knowledge acquisition and learning based on different design patterns and technologies. They will be able to decide on information representation (data level), design of functionalities (application level), and selection/configuration of algorithms to support platform users concerning challenges in the learning process. Students are capable to consider techniques of adaptation to learners needs and will know appropriate evaluation methods to measure the qualities and effects of learning applications and the algorithms and methods used in the learning applications.

**4 Prerequisite for participation**
Basic knowledge of Machine Learning and Natural Language Processing is desirable but not a prerequisite. For students who do not meet these requirements, we offer short learning modules that allow an understanding of the application-specific mechanisms.

**5 Form of examination**
Course related exam:
- [20-00-0773-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0773-iv] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>Kann in anderen Studiengängen verwendet werden. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Human and Identity centric Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1118 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. Arjan Kuijper |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1118-iv | Human and Identity centric Machine Learning | 0 | Integrated course | 4 |

**2 Teaching content**

Background and concepts of human-centric Machine Learning: the goal of identity and human-centric machine learning. The differences between identity learning and other
mainstream classification. Representation extraction for subject-related data: feature extraction methodology for identity related applications. Hand crafted and Deeply learned features background and
basics.

Deep learning strategies for identity representations: learning identities representations with deep learning. Learning strategies and learning losses. Network architectures and identityspecific components.

Knowledge transfer and distillation: transfer learning and identity-representation. Knowledge distillation concepts and applications.

Efficient machine learning: the relation between resource limitations, Green-AI, and deep learning. Methods to build efficient machine learning solutions.

Synthetic identity: the need of synthetic identity. Synthetic identity as adversarial. Generating synthetic identity-controlled data under different restrictions.

Machine learning biases: analyses of demographic fairness and the roots of the fairness issues. ML-based mitigation of demographic biases.

Learning privacy: analyzing unintentionally learned information. Learning strategies to the targeted suppression of information at different representation levels.

Data utility: understanding the effect of data utility in the training process. Understanding sample utility in operation. ML concepts and strategies of estimating sample utilities.

Sample-level attacks: overview on adversarial, sample manipulation, other attacks on human-centric ML. Deep learning concepts, network blocks, and loss strategies, to detect and mitigate sample-level attacks.

Explainability: overview on the need for explainability in different decision-making processes. Different strategies to provide explainability for decision made in different operations discussed in the previous lectures.

Ethics in identity-centric ML: overview on ethics in AI and AI regulation. AI ethics for human data processing and storage.

**3 Learning objectives**

| | |
|---|---|
| | After successfully attending the module, students are familiar with machine learning concepts related to dealing with human and identity related information. They understand fundamental techniques for the subject-specific representation extraction, including related knowledge transfer and distillation concepts. Understanding of demographic-related machine learning biases and function-creep privacy concerns, including their main mitigation concepts. They understand the requirements and techniques to achieve embedded and efficient human-centric machine learning. They are familiar with the effect of data utility in the training process and the main concept to estimate the utility of subject-related data.<br>They will have first hand understanding of explainability methodologies of ML decision based on identity-related data. The students will be introduced to AI ethics and AI regulation concepts related to human data processing and storage. They are able to implement these techniques in order to solve basic identity and human-centric machine learning tasks on realistic problems. |
| **4** | **Prerequisite for participation**<br>It is recommended having previously taken Visual Computing. Basics in mathematics and probability theory are required. |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-1118-iv] (Technical examination, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.<br>Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests). |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1118-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Model Predictive Control and Machine Learning | | | | | | |
| **Module nr.**<br>18-fi-2040 | **Credit points**<br>4 CP | **Workload**<br>120 h | **Self-study**<br>75 h | **Module duration**<br>1 Term | **Module cycle**<br>Winter term | |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr.-Ing. Rolf Findeisen | | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 18-fi-2040-vl | Model Predictive Control and Machine Learning | 0 | Lecture | 2 |
| 18-fi-2040-ue | Model Predictive Control and Machine Learning | 0 | Practice | 1 |

**2 Teaching content**

*Lecture:*
Introduction and basics of optimal control, Linear Quadratic Regulator (LQR) in discrete and continuous time, basics of model predictive control (cost functions, constraints, receding horizon), nominal model predictive control for linear systems, robust and stochastic model predictive control, model predictive control of nonlinear systems, combination of machine learning and model predictive control.

*Group work:*
In a group project, the students will apply the learned. The group project evolves a review of state of the art for the selected task, the selection of suitable model predictive control approach, and the implementation using python/Matlab. It includes a project report and is concluded by a project presentation.

**3 Learning objectives**

The students will understand the basics concepts of model predictive control. Furthermore, they are familiarized with machine learning approaches that can support model predictive controllers and possibly enhance the controller performance. This entails knowledge about theoretical questions such as stability in the nominal case, as well as extensions to the case of uncertain and disturbed systems. The students are enabled to design and implement model predictive controllers based on first principle/physical or data-based/machine learning based models. This entails the setup and design of the control structure as well as the tuning and identification of suitable parameters and cost functions of the controller.

**4 Prerequisite for participation**

Recommended: Basic concepts of control theory. Fundamentals of linear algebra, differential, and difference equations. Knowledge in Python and/or Matlab.

**5 Form of examination**

Module exam:
- Module exam (Technical examination, Oral/written examination, Duration: 90 Min., Default RS)

The examination takes place in form of a written exam (duration: 90 minutes). If one can estimate that less than 25 students register, the examination will be an oral examination (duration: 25 min.). The type of examination will be announced in the beginning of the lecture.

**6 Prerequisite for the award of credit points**

Passing the final module examination

**7 Grading**

Module exam:
- Module exam (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| **9** | **References**<br>• J. Rawlings, D. Mayne, and M. Diehl. Model predictive control: theory, computation, and design. Nob Hill Publishing.<br>• S. Rakovic, and W. Levine. Handbook of Model Predictive Control. Birkhäuser, 2018. |
| **10** | **Comment** |

**Module name**
Natural Language Processing and the Web

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0433 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0433-iv | Natural Language Processing and the Web | 0 | Integrated course | 4 |

**2 Teaching content**

The Web contains more than 10 billion indexable web pages, which can be retrieved via keyword search queries. The lecture will present natural language processing (NLP) methods to automatically process large amounts of unstructured text from the web and analyze the use of web data as a resource for other NLP tasks.

Key topics:

- Processing unstructured web content
- NLP basics: tokenization, part-of-speech tagging, stemming, lemmatization, chunking
- UIMA: principles and applications
- Web contents and their characteristics, incl. diverse genres such as personal web sites, news sites, blogs, forums, wikis
- The web as a corpus - innovative use of the web as a very large, distributed, interlinked, growing, and multilingual corpus
- NLP applications for the web
- Introduction to information retrieval
- Web information retrieval and natural language interfaces
- Web-based question answering
- Mining Web 2.0 sites such as Wikipedia, Wiktionary
- Quality assessment of web contents
- Multilingualism
- Internet of services: service retrieval
- Sentiment analysis and community mining
- Paraphrases, synonyms, semantic relatedness

**3 Learning objectives**

After attending this course, students are in a position to
- understand and differentiate between methods and approaches for processing unstructured text,
- reconstruct and explicate the principle of operation of web search engines,
- construct and analyze exemplary NLP applications for web data,
- analyze and evaluate the potential of using web contents to enhance NLP applications.

**4 Prerequisite for participation**

Basic knowledge in Algorithms and Data Structure
Programming in Java

**5 Form of examination**

Course related exam:
- [20-00-0433-iv] (Technical examination, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

| | |
|---|---|
| 7 | **Grading**<br>Course related exam:<br>• [20-00-0433-iv] (Technical examination, Oral/written examination, Weighting: 100 %) |
| 8 | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| 9 | **References**<br>- Kai-Uwe Carstensen, Christian Ebert, Cornelia Endriss, Susanne Jekat, Ralf Klabunde: Computerlinguistik und Sprachtechnologie. Eine Einführung. 3. Auflage. Heidelberg: Spektrum, 2009. ISBN: 978-3-8274-20123-7.<br>- http://www.linguistics.rub.de/CLBuch/<br>- T. Götz, O. Suhre: Design and implementation of the UIMA Common Analysis System, IBM Systems Journal 43(3): 476-489, 2004.<br>- Adam Kilgarriff, Gregory Grefenstette: Introduction to the Special Issue on the Web as Corpus, Computational Linguistics 29(3): 333-347, 2003.<br>- Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval, Cambridge: Cambridge University Press, 2008. ISBN: 978-0-521-86571-5. http://nlp.stanford.edu/IR-book/ |
| 10 | **Comment** |

**Module name**
Technology transfer and entrepreneurship with a focus on artificial intelligence

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1176 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1176-vl | Technology transfer and entrepreneurship with a focus on artificial intelligence | 0 | Lecture | 2 |

**2 Teaching content**
The module is aimed at all PhD students and students of TU Darmstadt from the 2nd semester onwards, especially those who are currently or in the future considering founding a start-up or spin-off. Parts of the lecture will take place remotely. It is planned to include entrepreneurs from practice in this context.
In terms of content, this module deals with methods for goal-oriented idea generation and their critical reflection, procedures for estimating the market and market potential, and the analysis of competitors. In addition, various business models and growth strategies are discussed and their implications for monetization and scalability are taught. Furthermore, the fundamentals of sales and marketing are taught, as well as the procurement of personnel, incentives and employee participation, acquisition of venture capital, corporate culture, operations and management, preparation of business plans, and legal principles and liability issues.

**3 Learning objectives**
Upon successful completion of the module, students will have learned the fundamentals of transferring scientific results to practical applications and will be able to apply the content taught.

**4 Prerequisite for participation**
No previous experience is required.

**5 Form of examination**
Course related exam:
- [20-00-1176-vl] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.
Written exam (duration 60 or 90 or 120 minutes), oral exam (duration 15 or 30 minutes), homework (optional: including tests).

**6 Prerequisite for the award of credit points**
Pass exam (100%).

**7 Grading**
Course related exam:
- [20-00-1176-vl] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

## 1.1.2 Study-related Achievements

### 1.1.2.1 Seminars

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Recent Topics in the Development and Application of Modern Robotic Systems | | | | | | |
| **Module nr.**<br>20-00-0148 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | | |
| 1 | **Courses of this module** | | | | | |
| | **Course nr.** | **Course name** | **Workload (CP)** | **Teaching form** | **HPW** | |
| | 20-00-0148-se | Recent Topics in the Development and Application of Modern Robotic Systems | 0 | Seminar | 2 | |
| 2 | **Teaching content**<br>- guided independent work on a concrete task from development and application of modern robotic systems<br>- becoming acquainted with the relevant state of research and technology<br>- development of a solution approach and its presentation and discussion in a talk and in a final report | | | | | |
| 3 | **Learning objectives**<br>Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems and train presentation and documentation skills. | | | | | |
| 4 | **Prerequisite for participation**<br>Basic knowledge in Robotics as given in lecture “Grundlagen der Robotik”. | | | | | |
| 5 | **Form of examination**<br>Course related exam:<br>• [20-00-0148-se] (Study achievement, Oral/written examination, Default RS) | | | | | |
| 6 | **Prerequisite for the award of credit points**<br>Pass exam (100%) | | | | | |
| 7 | **Grading**<br>Course related exam:<br>• [20-00-0148-se] (Study achievement, Oral/written examination, Weighting: 100 %) | | | | | |
| 8 | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>May be used in other degree programs. | | | | | |
| 9 | **References**<br>Will be given in lecture. | | | | | |
| 10 | **Comment** | | | | | |

**Module name**
Deep Learning and Digital Humanities

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1080 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1080-se | Deep Learning and Digital Humanities | 0 | Seminar | 2 |

**2 Teaching content**
Our focus will be on humanities applications such as Poetry Generation and Analysis, Metaphor Identification, analysis of emotions, and others, and how these can be solved with the help of Deep Learning techniques. Students will read papers and present them during the seminar.

**3 Learning objectives**
After this seminar, students will be able to:
* understand problems in the field of digital humanities
* understand how Deep Learning can used to solve these problems
* implement crowd-sourcing techniques for annotation

**4 Prerequisite for participation**
Lecture Deep Learning is helpful, but not required.

**5 Form of examination**
Course related exam:
- [20-00-1080-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1080-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Extended Seminar - Systems and Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1057 | 4 CP | 120 h | 75 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1057-se | Extended Seminar - Systems and Machine Learning | 0 | Seminar | 3 |

**2 Teaching content**
This seminar serves the purpose of discussing new research papers in the intersection of hardware/software-systems and machine learning. The seminar aims to elicit new connections amongst these fields and discusses important topics regarding systems questions machine learning including topics such as hardware accelerators for ML, distributed scalable ML systems, novel programming paradigms for ML, Automated ML approaches, as well as using ML for systems.

Every participant will present one research paper, which will be subsequently discussed by all participants. In addition, summary papers will be written in groups and submitted to a peer review process. The papers will typically be recent publications in relevant research venues and journals.

The seminar will be offered as a block seminar. Further information can be found at: http://binnig.name

**3 Learning objectives**
After this seminar, the students should be able to
- understand a new research contribution in the areas of the seminar
- prepare a written report and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

**4 Prerequisite for participation**
Basic knowledge in Machine Learning, Data Management, and Hardware-/Software-Systems.

**5 Form of examination**
Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1057-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B. Sc Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Extended Seminar - AI for Data Management

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1182 | 4 CP | 120 h | 75 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1182-se | Extended Seminar - AI for Data Management | 0 | Seminar | 3 |

**2 Teaching content**

Database management systems (DBMS) in the cloud are the backbone for managing large volumes of data efficiently and thus play a central role in business and science today. For providing high performance, many of the most complex DBMS components such as query optimizers or schedulers involve solving non-trivial problems.

To tackle such problems, very recent work has outlined a new direction of so-called learned DBMS components where AI-based methods are used to replace and enhance core DBMS components which has shown to provide significant performance benefits. This route is in particular interesting since Cloud vendors such as Google, Amazon, and Microsoft are already applying these techniques to optimize the performance their cloud data systems.

Furthermore, AI has also been used for improving many other data management related tasks such as data engineering tasks (e.g., error detection and correction in databases or data transformation and data augmentation) which typically cause high manual overhead and can be automated by the use of AI. Finally, AI has also been used for extending databases by better data access interfaces (e.g., natural languague querying and chatbots for data) or by supporting data beyond structured tabular data (i.e., text and images).

This seminar serves the purpose to understand the basic concepts of how AI can be used for data management. In the first part of the seminar, participants will learn the basics of AI for data management along with implementing a case study themselves. In the second part, every participant will select and present a recent research paper. The papers will typically be recent publications in relevant research venues and journals such as SIGMOD, VLDB or ICML, NeurIPS.

The seminar kick-off will typically be in the first two weeks of the semester where we discuss the organization of the seminar. Further information can be found at: http://tuda.systems

**3 Learning objectives**

After successfully completeing this module Students are able to

- apply basic concepts of AI to data management
- read and understand a new research contribution in the areas of the seminar
- prepare and present the results of such a paper in front of an audience
- participate in a discussion in the areas of the seminar
- to peer-review the results of other students

**4 Prerequisite for participation**

Recommended:
Basic knowledge in Machine Learning and programming in Python and ideally C++. Advanced knowledge in Data Management, and Database-Systems by attending courses such as SDMS or ADMS.

**5 Form of examination**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1182-se] (Study achievement, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:<br>Colloquium (optional: including presentation), Term Paper. |
| **6** | **Prerequisite for the award of credit points**<br>Pass Exam (100%). |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1182-se] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Advanced Topics in Computer Vision and Machine Learning | | | | | |
| **Module nr.**<br>20-00-0645 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr.-Ing. Michael Gösele | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0645-se | Advanced Topics in Computer Vision and Machine Learning | 0 | Seminar | 2 |

**2 Teaching content**

- Basics of scientific presentations and reviewing
- Independent familiarization with current publications in computer vision or machine learning (in English)
- Further research on background literature, with help from a mentor
- Preparation of a two-part slide presentation (problem statement and proposed solution) of one publication, with feedback from mentor
- Writing a scientific “mock” review of another publication, with aid from mentor
- Giving the presentation in front of a mixed audience
- Guiding the interactive discussion after both presentation parts
- Active participation in discussions, including feedback to presenters

**3 Learning objectives**

After successfully completing the seminar, students are able to use recent scientific publications to become acquainted with current topics in computer vision and/or machine learning in an independent fashion. They can recognize the key contributions of the publications and are able to present them to a heterogeneous audience, taking into account good practices of scientific presentation. They can direct a scientific discussion following the presentation. Moreover, they are able to author a scientific review following common standards of the scientific review process.

**4 Prerequisite for participation**

Teilnehmer sollten Grundkenntnisse in Computer Vision, sowie idealerweise maschinellem Lernen besitzen (z.B. durch Besuch von Computer Vision I, Maschinelles Lernen: Statistische Verfahren I).

**5 Form of examination**

Course related exam:

- [20-00-0645-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0645-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>B.Sc. Computational Engineering<br>M.Sc. Computational Engineering<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References**<br>Actual publications, mostly last year. |
| **10** | **Comment** |

| **Module name**<br>Humanoid Robotics | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-1125 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1125-se | Humanoid Robotics | 0 | Seminar | 2 |

**2 Teaching content**

In this seminar, we will discuss different problems from the field of humanoid robotics, e.g. concerning locomotion and whole-body control, planning, or perception. In the context of this seminar, students should acquire the ability to independently work out an unknown text, write a scientific article and present its content to an expert audience.

**3 Learning objectives**

Upon successful completion of the module, students will understand current research topics in humanoid robotics and will be able to:

- Independently familiarize themselves with a topic area based on scientific publications, and
- present their findings verbally and in writing to a professional audience.

**4 Prerequisite for participation**

Concurrent or prior enrollment in the course "Foundations of Robotics" and/or "Robot Learning" is recommended.

**5 Form of examination**

Course related exam:

- [20-00-1125-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:
Colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1125-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

| Module name<br>Intelligent Robotic Manipulation | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-1158 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1158-se | Intelligent Robotic Manipulation: Part I | 0 | Seminar | 2 |

**2 Teaching content**

This advanced seminar introduces fundamental algorithms for creating robot systems that can autonomously perceive and manipulate objects in unstructured environments like homes, restaurants, supermarkets, etc. It addresses the complex and timely challenge of understanding and developing intelligent robotic manipulation. The seminar will discuss fundamental methods in perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), and dynamics and control (mainly force control and its variants).

The seminar will contain a combination of introductory lectures and a reading group to discuss and learn about advanced algorithmic approaches in robotics. After an introductory lecture on a new topic, small groups of students will be assigned a research paper that is fundamental for each topic (depending on the class size, there might be an alternating style). The students shall present the basic concept of the paper in class and engage in discussion regarding the presented topics.

**3 Learning objectives**

After this advanced course, students will be able to understand the entire pipeline of robotic systems by being immersed in the details of the fundamental paradigm of perception, planning, and action for robotic manipulation. Students will then be familiar with various AI and control techniques that will enable them to solve challenging intelligent robot manipulation problems. The goal is a holistic understanding of the science of robotics for the field of manipulation.

**4 Prerequisite for participation**

Recommended:
The students should have fundamental knowledge in robotics, and linear algebra. Furthermore, Fundamentals of Robotics (20-00-0735-iv Grundlagen der Robotik) is recommended.

**5 Form of examination**

Course related exam:

- [20-00-1158-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:

Colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**

Pass exam (100%).

**7 Grading**

Course related exam:

- [20-00-1158-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Intelligent Robotic Manipulation: Part II

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1168 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1168-se | Intelligent Robotic Manipulation: Part II | 0 | Seminar | 2 |

**2 Teaching content**

This advanced seminar introduces fundamental algorithms for creating robot systems that can autonomously perceive and manipulate objects in unstructured environments like homes, restaurants, supermarkets, etc. It addresses the complex and timely challenge of understanding and developing intelligent robotic manipulation. The seminar will discuss fundamental methods in perception (including approaches based on deep learning and approaches based on 3D geometry), planning (robot kinematics and trajectory generation, collision-free motion planning, task-and-motion planning, and planning under uncertainty), and dynamics and control (mainly force control and its variants).

The seminar will contain a combination of introductory lectures and a reading group to discuss and learn about advanced algorithmic approaches in robotics. After an introductory lecture, small groups of students (or individuals) will be assigned a research paper that is fundamental for each topic (depending on the class size, there might be an alternating style). The students shall present the basic concept of the paper in class and engage in discussion regarding the presented topics.

Possibly, a specific theme will be selected every semester, that will be announced by the lecturer in Moodle.

List of topics (non-exhaustive):

- Refresher on kinematics and dynamics
- Pick-and-place pipeline
- Object pose estimation
- Grasp generation
- Robot force control (stiffness, impedance, admittance)
- Sampling-based motion planning
- Trajectory Optimization
- Task and Motion Planning
- Mobile Manipulation
- Human-Robot Interaction

**3 Learning objectives**

Students have the chance to gain knowledge in advanced topics in Robotics, AI and Learning. By presenting high-end robotics research papers, the students learn how to communicate effectively scientific topics, and they also will learn how to collaborate with their colleagues for preparing their presentation.

**4 Prerequisite for participation**

Recommended:
The students should have fundamental knowledge in robotics, and linear algebra. Furthermore, Fundamentals of Robotics (20-00-0735-iv Grundlagen der Robotik) is recommended.

**5 Form of examination**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1168-se] (Study achievement, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:<br>Colloquium (optional: including presentation), Term Paper. |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%). |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1168-se] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Seminar Data Mining and Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0102 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0102-se | Seminar Data Mining and Machine Learning | 0 | Seminar | 2 |

**2 Teaching content**
This seminar serves the purpose of discussing new research papers in the areas of data mining and machine learning. Every participant will present one paper, which will be subsequently discussed by all participants. Grades are based on the preparation and presentation of the paper, as well as the participation in the discussion, in some cases also a written report.

The papers will typically recent publications in relevant journals such as “Data Mining and Knowledge Discovery”, ""Machine Learning"", as well as ""Journal of Machine Learning Research"". Students may also propose their own topics if they fit the theme of the seminar.

Please note current announcements to this course at http://www.ke.informatik.tu-darmstadt.de/lehre.

**3 Learning objectives**
After this seminar, students should be able to
- understand an unknown text in the area of machine learning
- work out a presentation for an audience proficient in this field
- make useful contributions in a scientific discussion in the area of machine learning

**4 Prerequisite for participation**
Basic knowledge in Machine Learning and Data Mining

**5 Form of examination**
Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0102-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

| | |
|---|---|
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Software Engineering for Artificial Intelligence

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1097 | 4 CP | 120 h | 75 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr.-Ing. Ermira Mezini |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1097-se | Software Engineering for Artificial Intelligence | 0 | Seminar | 3 |

**2 Teaching content**

Data-driven artificial intelligence (AI) solutions are being adopted in many areas, including finance, medicine, cognitive sciences, and biology. Such machine learning (ML) approaches require an accurate domain and requirement analysis, proper software design and development, dedicated testing and debugging, as well as specific techniques that ensure scalability and maintainability. While AI-enabled systems continue to have a tremendous impact on many fields, developers and data scientists still follow methods (scripting, informal/non-written specifications, trial-and-error testing) that do not conform to the state of the art of engineering disciplines. In this context, it is of paramount importance to take advantage of the decades-long developments of software engineering (SE) to systematize the development process of ML solutions.

In this course, each student will be assigned a topic regarding SE for AI. Based on provided resources and personal extending research, each student prepares a presentation with following discussion. These will be conducted in regular appointments. The students not presenting at a particular date, prepare via introductory reading for the respective discussion. Grading will be based on the preparation of the assigned topic and its presentation, as well as on the participation in all the discussions.

For more information and announcements, please consult the course webpage: https://allprojects.github.io/SE4AI/

**3 Learning objectives**

After successful completion of the module students will have developed a deeper understanding of software engineering for artificial intelligence. This includes the key topics requirements engineering, quality assurance, development processes, and software architecture and design accounting for modularity, reusability, efficiency, scalability, fairness and privacy.

The students learn the preparation and the presentation of scientific contents for an audience with heterogeneous background knowledge. Moreover, students train efficient preparation of and active participation in scientific discussions as well as their moderation.

**4 Prerequisite for participation**

Recommended: Basic knowledge of software engineering. Interest in artificial intelligence.

**5 Form of examination**

Course related exam:

- [20-00-1097-se] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:
Colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1097-se] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Symbolic Execution | | | | | | |
| **Module nr.**<br>20-00-0702 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. rer. nat. Reiner Hähnle | | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0702-se | Symbolic Execution | 0 | Seminar | 2 |

**2 Teaching content**

Symbolic execution of programs is a fundamental analysis technique that forms the basis of test generation, compiler optimization, verification, visualization, etc. In recent years, major progress was made. In the seminar we review the most important classic as well as recent contributions to symbolic execution.

**3 Learning objectives**

Understanding the possibilities and the limitations of this fundamental program analysis technique.

**4 Prerequisite for participation**

**5 Form of examination**

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0702-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Text Analytics | | | | | | |
| **Module nr.**<br>20-00-0596 | **Credit points**<br>3 CP | **Workload**<br>90 h | **Self-study**<br>60 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. phil. Iryna Gurevych | | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0596-se | Text Analytics | 0 | Seminar | 2 |

**2 Teaching content**

The seminar introduces current topics in natural language processing. It provides a thorough introduction into state-of-the-art technology in text analytics. The main focus of the seminar changes each semester.

Further information: https://www.ukp.tu-darmstadt.de/teaching/courses/regular-seminar/

**3 Learning objectives**

After attending this course, students are in a position to
- name and explain state-of-the-art research questions in the area of the seminar,
- understand, critically assess, and discuss scientific publications,
- independently comprehend and work out a research topic and
- present it to the group and react on questions and discussion threads.

**4 Prerequisite for participation**

**5 Form of examination**

Course related exam:
- [20-00-0596-se] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-0596-se] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

Will be given in seminar.

**10 Comment**

**Module name**
Computational Neuroscience

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1129 | 3 CP | 90 h | 60 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. rer. nat. Michael Waidner |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1129-se | Computational Neuroscience | 0 | Seminar | 2 |

**2 Teaching content**

The subject of the seminar is the teaching of methods of model building for neuroscience. The functional systems of the nervous system, including the brain, are among the most complex networks of interactions that we can observe in nature. Moreover, biological neural networks are cognitive systems that are of particular interest to computer science for this reason alone. The modeling of neural systems can be readily applied to other non-biological systems (e.g., autonomous systems, transportation networks, logistics) and therefore serve as a suitable use case to develop appropriate methodological skills. In the seminar, we will address observable and simulatable nonlinear dynamics that are reciprocally coupled with each other in the nervous system on different time scales, such as neuronal electrical activities and activity-dependent plastic processes, which in turn change the activity flow on a much slower time scale. Using original publications, informatic and mathematical methods are taught to model such processes and systems. The above-mentioned models will be developed on different neuronal functional systems such as the visual or the hippocampal functional system for memory formation.

Offered as a virtual interactive event (WebEx) with seminar presentations as live stream

Recommended reading:
- Dynamical Systems in Neuroscience, Eugene M. Izhikevich, The MIT Press, ISBN 978-0-262-51420-0.
- The Rewiring Brain, Arjen van Ooyen & Markus Butz-Ostendorf, Academic Press/Elsevier. ISBN: 978-0-12-803784-3

**3 Learning objectives**

After successful completion of the module the student are able to
- describe neuronal functional systems in their parts and their functional relations.
- to compare different functional systems.
- to know mathematical methods for non-linear dynamics.
- implement ordinary differential equations for neural simulations.
- know different neuron and brain simulators
- abstract over biological details and develop a formal neuronal model.
- to know different neuronal models and to evaluate them for the respective application.

**4 Prerequisite for participation**

Recommended:
- Mathematical methods from the bachelor program in computer science
- Algorithms and data structures
- Programming skills (programming language freely selectable)
- Basic understanding of biology is an advantage

**5 Form of examination**

| | |
|---|---|
| | Course related exam:<br>• [20-00-1129-se] (Study achievement, Oral/written examination, Default RS)<br>The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible:<br>Colloquium (optional: including presentation). |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-1129-se] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

### 1.1.2.2 Practical Lab in Teaching

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Practical Lab in Teaching - Computational Engineering and Robotics | | | | | |
| **Module nr.**<br>20-00-0971 | **Credit points**<br>5 CP | **Workload**<br>150 h | **Self-study**<br>105 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0971-pl | Practical Lab in Teaching - Computational Engineering and Robotics | 0 | Internship teaching | 3 |

**2 Teaching content**

- Elaboration of new exercises and programming assignments
- Concepts for exercise sheets

**3 Learning objectives**

After successfully completing the course, the students are familiar with the preparation of teaching contents as excercises and programming assignments.

**4 Prerequisite for participation**

Prerequisite: Successful participation in "Introduction to Computational Engineering (and Robotics)"
Recommended: successful participation in "Foundations of Robotics"

**5 Form of examination**

Course related exam:

- [20-00-0971-pl] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0971-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

| **Module name**<br>Data Management - Teaching Lab | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-1040 | **Credit points**<br>5 CP | **Workload**<br>150 h | **Self-study**<br>105 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1040-pl | Data Management - Teaching Lab | 0 | Internship teaching | 3 |

**2 Teaching content**
Creation of lab exercises and teaching material

**3 Learning objectives**
Experience in the supervision of students on the topic of data management, especially with regard to using the newly created material.

**4 Prerequisite for participation**
Information Management (20-00-0015-iv)

**5 Form of examination**
Course related exam:
- [20-00-1040-pl] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1040-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik

**9 References**

**10 Comment**

**Module name**
Teaching Lab - Deep Learning for Natural Language Processing

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1044 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1044-pl | Teaching Lab - Deep Learning for Natural Language Processing | 0 | Internship teaching | 3 |

**2 Teaching content**
Organization of a shared tasks. In a shared task, the students are challenged to solve a current research problem. They will use methods they learned in the lecture to solve a certain problem as good as possible. The different solutions can be evaluated quantitatively to identify the best solution to the task. Your task is to select and prepare an appropriate dataset for the task and to give an introduction to the task. During the shared task, you are responsible to answer questions from the students and provide help if needed. After the submission, your task is to evaluate the submitted systems quantitatively and qualitatively. Besides the shared task, you support the weekly exercises, e.g., by answering student questions or by helping to grade the home exercises.

**3 Learning objectives**
The students work on problems that have both technical and didactic aspects and are involved in the implementation of the results they have developed.

**4 Prerequisite for participation**
Deep Learning for Natural Language Processing

**5 Form of examination**
Course related exam:
- [20-00-1044-pl] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1044-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

**Module name**
Practical Lab in Teaching - Introduction to Artificial Intelligence

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1132 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1132-pl | Practical Lab in Teaching - Introduction to Artificial Intelligence | 0 | Internship teaching | 3 |

**2 Teaching content**
This course deals with the teaching content of artificial intelligence, which is to be prepared didactically and made more comprehensible through accompanying practical exercises.

This includes, among other things:
- Designing and creating practical forms of exercises
- Offering office hours
- Supervising students
- Correcting exercise submissions
- Supporting the organization and realization of the exercises
- Making suggestions to improve the quality of teaching

**3 Learning objectives**
After successfully completing the modulee, students will be able to:
- Design and create practical exercises
- Prepare teaching content from the lecture for home and classroom exercises
- Support student groups didactically
- Critically question existing teaching materials and making suggestions for improvement
- Apply methods to evaluate the teaching success of the lecture content

**4 Prerequisite for participation**
Recommended: Successful completion of the course Introduction to Artificial Intelligence or equivalent knowledge.

**5 Form of examination**
Course related exam:
- [20-00-1132-pl] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1132-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

| | |
|---|---|
| | B.Sc. Informatik<br>M.Sc. Informatik<br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Teaching Lab - Foundations of Language Technology (FOLT)

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1110 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1110-pl | Teaching Lab - Foundations of Language Technology (FOLT) | 0 | Internship teaching | 3 |

**2 Teaching content**
Preparation, organization and correction of a shared tasks. Offering of office hours. Holding of tutorials and similar tasks in the context of teaching.

**3 Learning objectives**
After completing the course, the students are able to independently hold a tutorial, conduct shared tasks, and pursue similar tasks in the context of teaching.

**4 Prerequisite for participation**
Recommended: participation in previous Foundation of Language Technology (FOLT) courses or similar courses (e.g. Deep Learning for Natural Language Processing (DL4NLP))

**5 Form of examination**
Course related exam:
- [20-00-1110-pl] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1110-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Teaching Lab - Natural Language Processing

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1127 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1127-pl | Teaching Lab - Natural Language Processing | 0 | Internship teaching | 3 |

**2 Teaching content**
This module involves supporting a course on Natural Language Processing at the UKP lab. Tasks usually include creation, presentation, and correction of exercises and programming tasks or projects.

**3 Learning objectives**
After successful completion of the module, students will be able to:
- Prepare course content from the lecture for home and classroom exercises
- Design and create practical exercises
- Conceive and carry out exercises
- Develop a concept for practical exercises that build on each other
- Apply methods of learning control for the contents of the lecture

**4 Prerequisite for participation**
Recommended prerequisites: successful completion of the relevant course; good knowledge of Python and LaTeX

**5 Form of examination**
Course related exam:
- [20-00-1127-pl] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1127-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Practical Lab in Teaching - Optimization of Static and Dynamic Systems

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1085 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1085-pl | Practical Lab in Teaching - Optimization of Static and Dynamic Systems | 0 | Internship teaching | 3 |

**2 Teaching content**

- Elaboration of new exercises and programming assignments
- Concepts for exercise sheets

**3 Learning objectives**

After successfully completing the course, students can:

- Prepare teaching content from the lecture for home and classroom exercises as well as for programming tasks accompanying the lecture
- Develop a concept for practical exercises that build on one another
- Apply methods of learning control to the learning content of the lecture

**4 Prerequisite for participation**

Successful participation in "Optimization of static and dynamic systems" is recommended.

**5 Form of examination**

Course related exam:

- [20-00-1085-pl] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**7 Grading**

Course related exam:

- [20-00-1085-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

**Module name**
Practical Lab in Teaching - Statistical Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1070 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. Arjan Kuijper |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1070-pl | Practical Lab in Teaching - Statistical Machine Learning | 0 | Internship teaching | 3 |

**2 Teaching content**
Teaching support, such as supervision of exercise groups, consultations, etc.

**3 Learning objectives**
Preparation for future teachers' own teaching activities.

**4 Prerequisite for participation**
Successful completion of Statistical Machine Learning or corresponding knowledge.

**5 Form of examination**
Course related exam:
- [20-00-1070-pl] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-1070-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Teaching Lab - Visual Computing | | | | | |
| **Module nr.**<br>20-00-0519 | **Credit points**<br>5 CP | **Workload**<br>150 h | **Self-study**<br>105 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German | | | **Module owner**<br>Prof. Dr.-Ing. Michael Gösele | | |

| | | | | | |
|---|---|---|---|---|---|
| **1** | **Courses of this module** | | | | |
| | **Course nr.** | **Course name** | **Workload (CP)** | **Teaching form** | **HPW** |
| | 20-00-0519-pl | Praktikum in der Lehre - Visual Computing | 0 | Internship teaching | 3 |
| **2** | **Teaching content**<br>Assistance in organizing tutorials for Introduction to Human Computer Systems | | | | |
| **3** | **Learning objectives**<br>Creation and evaluation of teaching materials for courses in computer science and supervision of students. | | | | |
| **4** | **Prerequisite for participation**<br>Visul Computing | | | | |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-0519-pl] (Study achievement, Oral/written examination, Default RS) | | | | |
| **6** | **Prerequisite for the award of credit points**<br>Pass Exam (100%) | | | | |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-0519-pl] (Study achievement, Oral/written examination, Weighting: 100 %) | | | | |
| **8** | **Usability of the module** | | | | |
| **9** | **References** | | | | |
| **10** | **Comment** | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Practical Lab in Teaching - Visual Inference | | | | | |
| **Module nr.**<br>20-00-1131 | **Credit points**<br>5 CP | **Workload**<br>150 h | **Self-study**<br>105 h | **Module duration**<br>1 Term | **Module cycle**<br>Every Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. Arjan Kuijper | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1131-pl | Practical Lab in Teaching - Visual Inference | 0 | Internship teaching | 3 |

**2 Teaching content**
Creation of lab exercises and teaching material for courses of the FG Visual Inference

**3 Learning objectives**
After students have taken the module, they will be able to classify problems in exercises, evaluate them, and grade them correctly.

**4 Prerequisite for participation**
Recommended: successful participation of the lecture Computer Vision I (20-00-0157-iv) and/or Computer Vision II (20-00-0401-iv), depending on the semester.

**5 Form of examination**
Course related exam:
- [20-00-1131-pl] (Study achievement, Oral examination, Duration: 15 Min., Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible.

Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**
Pass exam 100%.

**7 Grading**
Course related exam:
- [20-00-1131-pl] (Study achievement, Oral examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Practical Lab in Teaching: Reinforcement Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1169 | 5 CP | 150 h | 105 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1169-pl | Practical Lab in Teaching: Reinforcement Learning | 0 | Internship teaching | 3 |

**2 Teaching content**
Support of teaching such as, supervision of exercise groups, office hours, or similar.

**3 Learning objectives**
Upon successful completion of the module students will have learned how to create and evaluate exercises, and will acquire professional experience in the organizational, aspects of an advanced course. They will also be able to further their experience in implementing and understanding problems in Reinforcement Learning by assisting in the creation of exercises.

**4 Prerequisite for participation**

**5 Form of examination**
Course related exam:
- [20-00-1169-pl] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Colloquium (optional: including presentation), portfolio, report (optional: including submission of course material).

**6 Prerequisite for the award of credit points**
Pass exam (100%).

**7 Grading**
Course related exam:
- [20-00-1169-pl] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

### 1.1.2.3 Labs, Project Labs, Related Courses

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Data Management - Lab | | | | | |
| **Module nr.**<br>20-00-1041 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1041-pr | Data Management - Lab | 0 | Internship | 4 |

**2 Teaching content**

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

**3 Learning objectives**

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

**4 Prerequisite for participation**

Depending on selected topic.

**5 Form of examination**

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-1041-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Data Management - Extended Lab | | | | | |
| **Module nr.**<br>20-00-1042 | **Credit points**<br>9 CP | **Workload**<br>270 h | **Self-study**<br>180 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1042-pp | Data Management - Extended Lab | 0 | Project | 6 |

**2 Teaching content**

Participants independently solve alone or in a small group an individually a given problem. The problems are usually programming projects inspired by the research performed at the Data Management Lab.

Possible areas are:
- Scalable Databases & Modern Hardware
- Cloud Databases & Blockchains
- Interactive Data and Text Exploration
- Natural Language Interfaces for Databases
- Scalable Systems for Machine Learning

In this lab the students will realise a project defined by their advisor. Compared to the "Data Management - Lab", the “Data Management - Extended Lab” requires more effort.

**3 Learning objectives**

After completion of this course the students are able to
- Understand state-of-the-art techniques in modern data management systems
- Apply and implemenation of techniques in individual projects
- Provide experimental evidence for design decisions with benchmarks and/or real workloads

**4 Prerequisite for participation**

Depending on selected topic.

**5 Form of examination**

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-1042-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Distributed Systems Programming: Lab

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0985 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Eberhard Mühlhäuser |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0985-pr | Distributed Systems Programming: Lab | 0 | Internship | 4 |

**2 Teaching content**

The course focuses on research topics in distributed systems (DS) and programming languages for DS. The offered topics depend on the current research of the DSP group including:

- Software-defined networking (SDN)
- Network function virtualization (NFV) and in-network processing (INP)
- Traffic engineering (TE)
- Network monitoring
- Resource management in datacenters (RMF)
- Big data analytics (Spark, YARN, OpenStack, ..)
- Event-based systems
- Security in SDN, INP, and big data
- Geo-distributed data processing
- Compiler infrastructures for DS
- Language abstractions for DS
- Session types / calculi for DS
- Network Protocols

In this project the students will realize their own/a group research project defined together with their adviser. Compared to the “DSP: Lab”, the “DSP: Project” requires more effort.

**3 Learning objectives**

After participating in the course, the student is able to solve and evaluate technical and scientific problems in designing and developing future DS concepts and applications using state of the art scientific methods.

Acquired competences include (depending on the selected topic):

- Literature research in the project area
- Design of complex DS
- Implementation and verification of components for DS
- Deep understanding of existing complex software systems
- Methodical analysis and evaluation of
  - Models
  - Experiments
  - Software
- Design of programming languages
- Writing of technical documents or project reports
- Research style presentation of the outcomes of the project

**4 Prerequisite for participation**

| | |
|---|---|
| | Interest to develop solutions for challenging problems of DS, self-motivation and high interest in recent research.<br><br>Due to the wide area of topics, we cannot offer a comprehensive list of requirements. All topics are research-oriented, hence topic-specific background knowledge is required. More details will be given in the first lecture. |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-0985-pr] (Study achievement, Oral/written examination, Default RS) |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-0985-pr] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module** |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Expert Lab on Robot Learning | | | | | |
| **Module nr.**<br>20-00-1108 | **Credit points**<br>9 CP | **Workload**<br>270 h | **Self-study**<br>180 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1108-pp | Expert Lab on Robot Learning | 0 | Project | 6 |

**2 Teaching content**

In this project, students perfect their ability at experimental work in an interdisciplinary team and become experts in scientific approaches to Robot Learning. In this project, small groups of students develop a common experiment in Robot Learning based on special robotic platforms, evaluate it and write a research report/paper that reaches the quality of a submission to an international scientific conference or journal.

**3 Learning objectives**

After completing the module, students can apply the practical skills of an expert in scientific studies on Robot Learning. They are able to analyze and synthesize experiments from the research idea up to the publication.

**4 Prerequisite for participation**

Recommended: Successful completion of Robot Learning: Integrated Project - Part 1 and Robot Learning: Integrated Project - Part 2.

**5 Form of examination**

Course related exam:

- [20-00-1108-pp] (Technical examination, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Report (optional: including submission of source code), colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1108-pp] (Technical examination, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Research Project Knowledge Engineering and Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0751 | 12 CP | 360 h | 240 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0751-pj | Research Project in Knowledge Engineering and Machine Learning | 0 | Project | 8 |

**2 Teaching content**
Through an individual project, students are tutored to autonomously conduct research in knowledge engineering, artificial intelligence, machine learning or data mining
The research topics will be defined in collaboration with their tutor.

Possible areas:
- Machine Learning and Data Mining
- Inductive Rule Learning
- Learning from Preferences
- Multilabel Classification
- Information Extraction
- Web Mining
- Semantic Web
- Game Playing

Concrete tasks will be assigned on an individual basis. The project can be started at any time.

Students that are interested in such a project, please contact a staff member of the Knowledge Engineering group (http://www.ke.tu-darmstadt.de).

**3 Learning objectives**
After completion of this project, students should be able to
- autonomously conduct small research projects in the areas knowledge engineering, artificial intelligence, maschine learning and data mining
- document the achieved results in a report
- present them in a scientific talk
- defend them in a critical discussion

**4 Prerequisite for participation**
Basic knowledge in Knowledge Engineering , Artificial Intelligence and Machine Learning is helpful.
Java or similar is expected.
Self-motivated and highly interested in actual research.

**5 Form of examination**
Course related exam:
- [20-00-0751-pj] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**

| | |
|---|---|
| | Course related exam:<br>• [20-00-0751-pj] (Study achievement, Oral/written examination, Weighting: 100 %) |
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>Can be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

**Module name**
Advanced Visual Computing Lab

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0537 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. Bernt Schiele |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0537-pr | Advanced Visual Computing Lab | 0 | Internship | 4 |

**2 Teaching content**
Students work in this lab on selected advanced topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.

**3 Learning objectives**
After successful completion of this course, the students will be able to independently analyze and solve an advanced problem in the area of visual computing and to evaluate the results.

**4 Prerequisite for participation**
Programming skills, e.g. Java, C++
Basic knowledge in Visula Computing
Participation in at least one basic lectures and one lab in the are of Visual Computing.

**5 Form of examination**
Course related exam:
- [20-00-0537-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0537-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**
Will be announced in lecture.

**10 Comment**

**Module name**
Integrated Robotics Project 1

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0324 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0324-pr | Integrated Robotics Project (Part 1) | 0 | Internship | 4 |

**2 Teaching content**
- guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers
- becoming acquainted with the relevant state of research and technology
- development of a solution approach and its implementation
- application and evaluation based on robot experiments or simulations
- documentation of task, approach, implementation and results in a final report and conduction of a final presentation

**3 Learning objectives**
Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.

**4 Prerequisite for participation**
- basic knowledge within Robotics as given in lecture “Grundlagen der Robotik”
- programming skills depending on task

**5 Form of examination**
Course related exam:
- [20-00-0324-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0324-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

**9 References**
Will be given in lecture.

| | |
|---|---|
| **10** | **Comment** |

**Module name**
Integrated Robotics Project 2

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0357 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0357-pr | Integrated Project (Part 2) | 0 | Internship | 4 |

**2 Teaching content**
- guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers
- becoming acquainted with the relevant state of research and technology
- development of a solution approach and its implementation
- application and evaluation based on robot experiments or simulations
- documentation of task, approach, implementation and results in a final report and conduction of a final presentation

**3 Learning objectives**
Through successful participation students acquire deepened knowledge in selected areas, subsystems and methods of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.

**4 Prerequisite for participation**
- basic knowledge within Robotics as given in lecture “Grundlagen der Robotik”
- programming skills depending on task
- Participation in "Integriertes Robotik-Project 1"

**5 Form of examination**
Course related exam:
- [20-00-0357-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0357-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

| | |
|---|---|
| | Will be given in course. |
| **10** | **Comment** |

**Module name**
Robot Learning: Integrated Project - Part 1

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0753 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0753-pj | Robot Learning: Integrated Project - Part 1 | 0 | Project | 4 |

**2 Teaching content**
In "Robot Learning: Integrated Project, Part 1", students will pose a current research problem in the domain of robot learning with assistance of their advisor. The students will select a robot learning topic to fit their research interests, on which they will pursue in-depth literature studies. Using these results, they will develop a plan for their project, try out the algorithms of interest and implement a prototype in simulation.

**3 Learning objectives**
Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.

**4 Prerequisite for participation**
Previous or concurrent participation in the lecture "Robot Learning".

**5 Form of examination**
Course related exam:
- [20-00-0753-pj] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0753-pj] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Robot Learning: Integrated Project - Part 2

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0754 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0754-pj | Robot Learning: Integrated Project - Part 2 | 0 | Project | 4 |

**2 Teaching content**
In "Robot Learning: Integrated Project, Part 2", students will complete their approach to the research problem from Part 1 and apply it to a real robot. A scientific article on the research problem, methods and results will be written and potentially submitted to a national or international scientific venue.

**3 Learning objectives**
Upon successful completion of this course, students will be able to independently develop small research projects in the domain of robot learning and test first research ideas in simulation.

**4 Prerequisite for participation**
Previous or concurrent participation in the lecture "Robot Learning".

**5 Form of examination**
Course related exam:
- [20-00-0754-pj] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0754-pj] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

**10 Comment**

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Practical Course in Artificial Intelligence | | | | | |
| **Module nr.**<br>20-00-0412 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0412-pr | Practical Course in Artificial Intelligence | 0 | Internship | 4 |

**2 Teaching content**

Students have to work on a concrete practical problem in the area of artificial intelligence and solve it with the help of tools and techniques that they developed on their own or that are already publicly available.

Note the announcements on the homepage of the KE group regarding this course (http://www.ke.informatik.tu-darmstadt.de/lehre/)!
In semesters, where this course is not announced on the above pages, there is often the possibility of individual projects (please ask).

**3 Learning objectives**

After completion of this practical course, students should be able to
- recognize potential uses of artificial intelligence tools
- select appropriate tools for a given task and apply them to this task
- evaluate and measure the success of the use of such tools

**4 Prerequisite for participation**

Basic knowledge in artificial intelligence

**5 Form of examination**

Course related exam:
- [20-00-0412-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:
- [20-00-0412-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

**10 Comment**

| **Module name**<br>Visual Computing Lab | | | | | |
|---|---|---|---|---|---|
| **Module nr.**<br>20-00-0418 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. Bernt Schiele | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0418-pr | Lab Visual Computing | 0 | Internship | 4 |

**2 Teaching content**

Students work in this lab on selected topics in the area of visual computing. Project results will be presented in a talk at the end of the course. The specific topics addressed in the lab change every semester and should be discussed directly with one of the instructors.

**3 Learning objectives**

After successful completion of this course, the students will be able to independently analyze and solve a problem in the area of visual computing and to evaluate the results.

**4 Prerequisite for participation**

Practical programming skills, e.g. Java, C++
Basic knowledge or interest within Visual Computing
Participation in one basic lecture within Visiual Computing

**5 Form of examination**

Course related exam:

- [20-00-0418-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0418-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

Can be used in other degree programs.

**9 References**

Will be announced in course.

**10 Comment**

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Practical Lab on Intelligent Robot Manipulation | | | | | |
| **Module nr.**<br>20-00-1159 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>English | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1159-pr | Practical Lab on Intelligent Robotic Manipulation: Part I | 0 | Internship | 4 |

**2 Teaching content**

This practical lab is offered in combination with the Advanced Seminar. Students that select this module should work in a group to implement a pipeline for robotic manipulation based on the methodologies and papers presented in the Advanced Seminar.

The individual topic will be decided between the lecturer and the students, and it should be implemented in principle in simulation using tools like ROS, Gazebo, and MoveIt! Library.
Depending on the conditions, students may also have the possibility to apply their pipeline to a real robot. Knowledge of Python is a plus, but students could exercise their skills in programming during the practical lab.

**3 Learning objectives**

At the end of this practical lab, students will be able to implement a holistic system that can solve robot manipulation tasks through perception, planning, and control.

**4 Prerequisite for participation**

Reccommended:
Participation in the Seminar on Intelligent Robotic Manipulation.

**5 Form of examination**

Course related exam:

- [20-00-1159-pr] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Report (optional: including submission of source code), colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-1159-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Lab on intelligent Robotic Manipulation: : Part II

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-1170 | 6 CP | 180 h | 120 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-1170-pr | Lab on intelligent Robotic Manipulation: : Part II | 0 | Internship | 4 |

**2 Teaching content**
In this project, individuals or groups of two-three students are able to gain in depth experience working towards a scientific project in the area of AI robotic manipulation. The topic is decided between the supervisor and the students, and it aims towards fundamental progress in the ares of robotic perception, control, planning and general decision-making for robotic manipulation, mobile manipulation or human-robot interaction. The students are expected to work in simulation and on real robotic platforms, and collaborate with our team that has interdisciplinary expertise. The students are expected to write a research report/paper at the quality of a submission to an international scientific conference or journal, which will be peer-reviewed by our team and other students.

**3 Learning objectives**
The students will work on cutting-edge research topics, and will get the opportunity to get a glimpse into scientific research, from investigating the related literature, to implementing already existing approaches, developing critical thinking for assessing the quality of obtained results. On a practical level, they will augment their skills in coding, and they will gain experience with working on real robotic manipulation problems.

**4 Prerequisite for participation**

**5 Form of examination**
Course related exam:
- [20-00-1170-pr] (Study achievement, Oral/written examination, Default RS)

The form of the examination will be announced at the beginning of the course. One or a combination of max. two of the following forms is possible. Report (optional: including submission of source code), colloquium (optional: including presentation).

**6 Prerequisite for the award of credit points**
Pass exam (100%).

**7 Grading**
Course related exam:
- [20-00-1170-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
May be used in other degree programs.

**9 References**

**10 Comment**

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Practical Exercises for Neural Information Processing for Brain-Computer Interfaces | | | | | |
| **Module nr.**<br>20-00-0945 | **Credit points**<br>6 CP | **Workload**<br>180 h | **Self-study**<br>120 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr. rer. nat. Oskar von Stryk | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0945-pr | Practical Exercises for Neural Information Processing for Brain-Computer Interfaces | 0 | Internship | 4 |

**2 Teaching content**

* Lab exercises for signal processing for neuroimaging
* Lab exercises for pattern recognition in neuroimaging
* Lab exercises for Brain-computer interfaces

**3 Learning objectives**

Based on the lecture "Neural Information Processing for Brain-Computer Interfaces", this lab course provides students with the practical abilities needed for projects in the domain of neural engineering.

**4 Prerequisite for participation**

Successful prior completion of the lecture "Neural Information Processing for Brain-Computer Interfaces"

**5 Form of examination**

Course related exam:

- [20-00-0945-pr] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0945-pr] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

**Module name**
Practical Project Knowledge Engineering and Machine Learning

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0919 | 9 CP | 270 h | 180 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. techn. Johannes Fürnkranz |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0919-pp | Practical Project Knowledge Engineering and Machine Learning | 0 | Project | 6 |

**2 Teaching content**
In the course of this practical project, students implement a larger, predefined task in the areas of knowledge engineering, artificial intelligence, machine learning or data mining. The topics will be defined in collaboration with their tutor.

Possible areas:
- Machine Learning and Data Mining
- Inductive Rule Learning
- Learning from Preferences
- Multilabel Classification
- Information Extraction
- Web Mining
- Semantic Web
- Game Playing

Concrete tasks will be assigned on an individual basis. The project can be started at any time.

Students that are interested in such a project, please contact a staff member of the Knowledge Engineering group (http://www.ke.tu-darmstadt.de).

**3 Learning objectives**
After completion of this project, students should be able to
- autonomously program larger research projects in the areas knowledge engineering, artificial intelligence, maschine learning and data mining
- conduct scientific experiments and evaluations using the implemented instruments

**4 Prerequisite for participation**
Basic knowledge in Knowledge Engineering, Artificial Intelligence, Data Mining and Machine Learning.
Basic knowledge in programming (e.g. Java).
Autonomous work and Interest on actual research.

**5 Form of examination**
Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0919-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

| | |
|---|---|
| **8** | **Usability of the module**<br>B.Sc. Informatik<br>M.Sc. Informatik<br>M.Sc. Wirtschaftsinformatik<br>B.Sc. Psychologie in IT<br>Joint B.A. Informatik<br>B.Sc. Sportwissenschaft und Informatik<br>M.Sc. Sportwissenschaft und Informatik<br><br>May be used in other degree programs. |
| **9** | **References** |
| **10** | **Comment** |

| | | | | | |
|---|---|---|---|---|---|
| **Module name**<br>Project Lab Deep Learning in Computer Vision | | | | | |
| **Module nr.**<br>20-00-0980 | **Credit points**<br>9 CP | **Workload**<br>270 h | **Self-study**<br>180 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester |
| **Language**<br>German/English | | | **Module owner**<br>Prof. Dr.-Ing. Michael Gösele | | |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0980-pp | Project Lab Deep Learning in Computer Vision | 0 | Internship | 6 |

**2 Teaching content**

In this project lab groups of students will work on selected topics in deep learning (deep neural networks) for problems in computer vision. This includes the practical implementation with modern deep learning frameworks. Results will be presented in a talk at the end of the lab. Concrete topics follow the current state of the art and change from term to term.

**3 Learning objectives**

Through their successful participation, students acquire in-depth knowledge on deep neural networks and their applications in computer vision. They are able to analyze, modify, and apply state-of-the-art techniques in this area. Moreover, they practice their abilities for presenting their results and for collaboration in teams.

**4 Prerequisite for participation**

* Solid programming skills in C/C++ or Python or Lua
* Prior or concurrent registration for "Computer Vision I"

**5 Form of examination**

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**

Pass exam (100%)

**7 Grading**

Course related exam:

- [20-00-0980-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Module name**<br>Project Lab E-Learning | | | | | | |
| **Module nr.**<br>20-00-0979 | **Credit points**<br>9 CP | **Workload**<br>270 h | **Self-study**<br>180 h | **Module duration**<br>1 Term | **Module cycle**<br>Every 2. Semester | |
| **Language**<br>German | | | **Module owner**<br>Prof. Dr. techn. Johannes Fürnkranz | | | |

| | | | | | |
|---|---|---|---|---|---|
| **1** | **Courses of this module** | | | | |
| | **Course nr.** | **Course name** | **Workload (CP)** | **Teaching form** | **HPW** |
| | 20-00-0979-pp | Project Lab E-Learning | 0 | Internship | 6 |
| **2** | **Teaching content**<br>Within the project lab, advanced e-learning content will be created, or existing e-learning elements will be evaluated and improved. The concrete focus is defined individually together with the supervisor. The range of topics includes the development of innovative concepts for using Moodle in lectures, the visualisation of algorithms and data structures, or the development of e-learning units using an authoring software. | | | | |
| **3** | **Learning objectives**<br>After the project lab, participants will have a better understanding of e-learning and more in depth knowledge about the design and implementation of e-learning that aids learners. | | | | |
| **4** | **Prerequisite for participation**<br>The lab requires good programming skills in Java (or, depending on the chosen topic, the How to Design Programming Languages used in the FOP lecture, or Moodle), as well as familiarity with standard data structures and algorithms, for example as taught in the AuD lecture. | | | | |
| **5** | **Form of examination**<br>Course related exam:<br>• [20-00-0979-pp] (Study achievement, Oral/written examination, Default RS) | | | | |
| **6** | **Prerequisite for the award of credit points**<br>Pass exam (100%) | | | | |
| **7** | **Grading**<br>Course related exam:<br>• [20-00-0979-pp] (Study achievement, Oral/written examination, Weighting: 100 %) | | | | |
| **8** | **Usability of the module** | | | | |
| **9** | **References** | | | | |
| **10** | **Comment** | | | | |

**Module name**
Robotics Lab Project

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0248 | 9 CP | 270 h | 180 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| German/English | Prof. Dr. rer. nat. Oskar von Stryk |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0248-pp | Robotics Project | 0 | Project | 6 |

**2 Teaching content**
- guided independent work on a concrete task from development and application of modern robotic systems and, as far as possible, as member of a team of developers
- development of a solution approach and its implementation
- application and evaluation based on robot experiments or simulations
- documentation of task, approach, implementation and results in a final report and conduction of a final presentation

**3 Learning objectives**
Through successful participation students acquire deepened knowledge in selected areas and subsystems of modern robotic systems as well as in-depth skills for development, implementation, and experimental evaluation. They train presentation skills and, as far as possible, team work.

**4 Prerequisite for participation**
- basic knowledge within Robotics as given in lecture “Grundlagen der Robotik”
- programming skills depending on task

**5 Form of examination**
Course related exam:
- [20-00-0248-pp] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0248-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**
B.Sc. Informatik
M.Sc. Informatik
B.Sc. Computational Engineering
M.Sc. Computational Engineering
M.Sc. Wirtschaftsinformatik
B.Sc. Psychologie in IT
Joint B.A. Informatik
B.Sc. Sportwissenschaft und Informatik
M.Sc. Sportwissenschaft und Informatik

May be used in other degree programs.

**9 References**

**10 Comment**

**Module name**
Data Analysis Software Project for Natural Language

| Module nr. | Credit points | Workload | Self-study | Module duration | Module cycle |
|---|---|---|---|---|---|
| 20-00-0948 | 9 CP | 270 h | 180 h | 1 Term | Every 2. Semester |

| Language | Module owner |
|---|---|
| English | Prof. Dr. phil. Iryna Gurevych |

**1 Courses of this module**

| Course nr. | Course name | Workload (CP) | Teaching form | HPW |
|---|---|---|---|---|
| 20-00-0948-pp | Data Analysis Software Project for Natural Language | 0 | Internship | 6 |

**2 Teaching content**
Big datasets have turned to highly valuable information sources nowadays. Intelligent data analysis is the key to unlock their actual value. Such analysis can help to obtain new and useful information and support decision making processes. In this project, students will develop own ideas and build novel software systems to extract useful information from a given dataset of natural language text, i.e. textual Big-Data.

The topic of each semester‘s course can be found on the course website at https://www.ukp.tu-darmstadt.de/teaching/courses/software-project/

**3 Learning objectives**
After completion of the project, the students are able to
- understand practical aspects for natural language processing
- develop own NLP-systems,
- analyze big datasets of natural language text, and
- use state-of-the-art frameworks and technology for natural language processing.

**4 Prerequisite for participation**
- Programming skills (Scala, Java or Python)
- Interest in working with natural language text

**5 Form of examination**
Course related exam:
- [20-00-0948-pp] (Study achievement, Oral/written examination, Default RS)

**6 Prerequisite for the award of credit points**
Pass exam (100%)

**7 Grading**
Course related exam:
- [20-00-0948-pp] (Study achievement, Oral/written examination, Weighting: 100 %)

**8 Usability of the module**

**9 References**

**10 Comment**

## 1.2 Studium Generale