Master of Science in Computer Science

Semester Range: SS 2025 - WS 2026/27
Creation Date: April (SS 2026)

Lecture Overview

Number of modules offered in English language: 70

Lecture Name	Last Semester	Regularly	Credits
AI Foundation Models in Biomedicine	WS 2025/26	Winter	5
Advanced Natural Language Processing	SS 2025	Summer	3
Application-Specific Instruction-Set Processors	WS 2025/26	Winter	5
Applied Machine Learning in Genomic Data Science	WS 2025/26	Winter	5
AutoML Lab	WS 2025/26	Winter	6
Automated Machine Learning	SS 2025	Summer	5
Computability and Logic	SS 2027	Summer	7
Computational Argumentation	SS 2025	Summer	5
Creation and Application of Knowledge Graphs	WS 2025/26	Winter	5
Deep Learning Foundations	WS 2025/26	Winter	5
Digital Image Processing	SS 2025	Summer	5
Distributed Real-time Systems	SS 2025	Summer	5
Efficient Algorithms	WS 2025/26	Winter	7
Federated Learning	WS 2025/26	Winter	5
Formal Languages	SS 2027	Summer	7
Foundations of Information Retrieval	WS 2025/26	Winter	5
Graph Signal Processing	SS 2025	Summer	5
Hardware-accelerated Communication Systems	WS 2025/26	Winter	5
Image Analysis I	SS 2025	Summer	5
Image Analysis II	WS 2025/26	Winter	5
Image Sequence Analysis	WS 2025/26	Winter	5
Interpretable Machine Learning	WS 2025/26	Winter	5
Introduction to Natural Language Processing	SS 2025	Summer	5
Knowledge Engineering and Semantic Web	SS 2025	Summer	5
Computational Complexity	WS 2025/26	Winter	7
Cryptography	WS 2026/27	Winter	7

Artificial Intelligence I	SS 2025	Summer	5
Artificial Intelligence II	WS 2025/26	Winter	5
Lab: Argumentation Technology	SS 2025	Summer	6
Lab: Human Language Technology	WS 2025/26	Winter	6
Laboratory Reborn Articles	WS 2025/26	Both	6
Laserscanning	WS 2025/26	Winter	5
Advanced Logics	SS 2026	Summer	7
Methods of User Authentication	WS 2025/26	Winter	3
Mobile Interaction	SS 2025	Summer	5
Multi-Agent Communication Systems	SS 2025	Summer	5
Multi-Agent Interactions and Games	WS 2025/26	Winter	5
Production of Optoelectronic Systems	WS 2025/26	Winter	5
ASIPLab: Design of Application-Specific Instruction-Set Processors	SS 2025	Summer	6
Project: Ethical Artificial Intelligence	WS 2025/26	Winter	6
Project: Machine Learning	WS 2025/26	Winter	6
Project: Reinforcement Learning	WS 2025/26	Winter	6
Quantum Computing	WS 2026/27	Winter	7
Quantum Information Processing	SS 2025	Summer	5
Reinforcement Learning	SS 2025	Summer	5
Research Methods for Autonomous and Intelligent Systems	SS 2025	Summer	5
Robotics I	WS 2025/26	Winter	5
SLAM (Simultaneous Localization and Mapping) and Path Planning	WS 2025/26	Winter	5
Scientific Data Management and Knowledge Graphs	WS 2025/26	Winter	5
Seminar on Scientific Data Management	SS 2025	Summer	3
Seminar: Artificial Intelligence	WS 2025/26	Both	3
Artificial Intelligence in Education	SS 2025	Summer	3
Seminar: Cryptographic Foundations of Secure Messaging	WS 2025/26	Winter	3
Hybrid Artificial Intelligence	SS 2025	Summer	3
Conference Seminar Usable Security and Privacy	WS 2025/26	Winter	3
Seminar: Natural Language Generation	SS 2025	Summer	3

Seminar: Quantum Information	WS 2025/26	Winter	3
Seminar: Solving Complex Tasks using Large Language Models	WS 2025/26	Winter	3
Seminar: Dependable and Scalable Systems	SS 2025	Summer	3
Seminar: Distributed Real-time Systems	WS 2025/26	Winter	3
Mobile System Security	WS 2025/26	Winter	5
Side-Channel Attacks and Defenses	WS 2025/26	Winter	5
Social Computing	SS 2025	Summer	5
Social Responsibility in Machine Learning	SS 2026	Summer	5
Spatial Data Science	SS 2025	Summer	5
Statistical Natural Language Processing	WS 2025/26	Winter	5
Text Mining	SS 2025	Summer	5
Circuit Complexity	SS 2026	Summer	7
Parameterized Complexity Theory	WS 2026/27	Winter	7

AI Foundation Models in Biomedicine

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Tang (tang@l3s.de)

Learning Objectives: Foundation models represent a new wave in AI, with ChatGPT as a classical example. Foundation models replace task-specific models by training on a broad set of unlabelled data, enabling versatile applications with minimal fine-tuning required. The learning aims are: (1) to grasp the fundamentals of AI foundation models; (2) to explore how they can be applied in the biomedical domain, particularly in genomics and proteomics, and how they can contribute to treatments for diseases like cancer and Alzheimer's; (3) to inspire interests in this interdisciplinary field, which will impact us profoundly in the next 5-10 years. Master students or advanced bachelor students with basic knowledge in python and deep learning are encouraged to join the course.

Syllabus: We will first introduce foundation models, and various biomedical challenges such as cancer and drug design. Then we will dive into specific examples of foundation models that were developed on DNA, RNA , protein or medical images. In the end we will also discuss the challenges in the field and offer insights into future prospects.

Advanced Natural Language Processing

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: D’Souza (jennifer.dsouza@tib.eu)

Learning Objectives: This course teaches students to understand and apply deep learning methods for natural language processing, with a particular emphasis on large language models (LLMs). Students will spend most of the term exploring neural language models and transfer learning, both key drivers in advancing the state of the art in the field. It is designed for Masters students in computer science or informatics who are (1) interested in keeping pace with cutting-edge research developments in NLP and (2) have a solid background in machine learning fundamentals. The course will delve into modeling architectures, training objectives, and a variety of downstream tasks such as text classification, question answering, text generation, and information extraction. Coursework includes reading recent research papers and completing assignments.

Syllabus: Lecture parts:
- introduction, language modeling.
- neural language models, backpropagation.
- attention mechanisms and Transformers.
- LLM pretrain/finetune.
- Tokenization and efficient fine-tuning.
- LLM alignment.
- Decoding from language models.
- Prompt engineering and evaluation.
- Scaling LLMs.
- Vision-language models, understanding in-context learning.

Application-Specific Instruction-Set Processors

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Blume, Cholewa (blume@ims.uni-hannover.de; cholewa@ims.uni-hannover.de)

Learning Objectives: Die Studierenden kennen die erweiterte Prozessorarchitektur (Instruction-, Data-, und Task-Level-Parallelism). Sie sind fähig zur Umsetzung von anwendungsspezifischen Instruktionssatz-Prozessoren (ASIPs). Sie können Arithmetik-orientierten Hardware-Erweiterungen implementieren. Sie kennen neuartige Entwicklungstendenzen von Prozessoren, wie z.B. hochparallele Prozessoren und rekonfigurierbare Prozessoren.

Syllabus: 1. Introduction to Embedded Computer Architectures.
2. Fundamentals of Processor Design.
3. Application-Specific Instruction-Set Processor (ASIP). Customizable processors.
4. Computer Arithmetics. Hardware acceleration of complex arithmetic functions.
5. Reconfigurable Processor Architectures.
6. Approximate and Stochastic Processor Architectures.
7. Fault-Tolerant Processor Architectures.
8. Cryptographic Processor Architectures.
9. Neuromorphic Processor Architectures. AI Processor Architectures.

Special Features: Diese Vorlesung wird auf Englisch gehalten. Die Übungen bestehen aus Hörsaalübungen.

Applied Machine Learning in Genomic Data Science

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Voges (voges@tnt.uni-hannover.de)

Learning Objectives: The combined field of machine learning, genomics, and data science has witnessed a remarkable rise in recent years, transforming the landscape of biomedical research and healthcare, and revolutionizing our understanding of disease mechanisms and drug development, paving the way for precision medicine.

In this course, students will enhance their understanding of how machine learning techniques can be applied to analyze and interpret biological data, specifically in the context of genomics.

The key goals that students can expect to achieve are:
1) This course will provide students with a solid foundation in basic concepts and techniques used in genomic data science.
2) Students will learn about various machine learning algorithms. They will gain an understanding of how these algorithms work and when to apply them to different types of data.
3) Students will learn how to preprocess and prepare genomic data for machine learning tasks, choose appropriate features, train, and evaluate models, and interpret the results.

By the end of the course, students will have a solid understanding of how machine learning can be applied to genomics and related areas, enabling them to explore further research and career opportunities in this exciting and rapidly evolving field.

Syllabus: • Course Overview and Objectives: Introduction to the landscape of machine learning in genomics,
learning outcomes, and course structure.
• Foundations of Molecular Biology for Data Scientists: Key biological concepts—DNA, RNA,
transcription, translation, etc.—tailored for computational audiences.
• DNA Sequencing Technologies and Data Characteristics: Overview of high-throughput technologies
(e.g., Illumina, Nanopore) and implications for data analysis.
• Fundamentals of Information Theory in Genomics: Statistics, entropy, and

compression—tools to
quantify and analyze biological sequences.

- Core Concepts in Machine Learning: Supervised and unsupervised learning, model evaluation, overfitting, regularization, and more.
- Introduction to Neural Networks and Deep Learning: Architecture, activation functions, optimization, and overviews of key models.
- Machine Learning Models in Computational Biology: Classical and deep learning models applied to sequence classification, motif discovery, and more.
- RNA Sequencing and Expression Quantification: From raw reads to gene expression matrices, differential expression, and normalization techniques.
- Application Case Study I: 3D Genome Reconstruction: Modeling chromatin architecture using chromosome conformation capture techniques.
- Application Case Study II: Single-Cell Perturbation Modeling: Predicting perturbation outcomes using transformers and diffusion models in single-cell RNA sequencing data.

Special Features: keine

AutoML Lab

Credits: 6

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden haben gelernt, wie automatisches maschinelles Lernen in der Praxis auf neue Problemstellungen angewendet wird. Dazu gehören sowohl Hyperparameter-Optimierung als auch Architektursuche von neuronalen Netzen. Sie können sowohl existierende AutoML Tools angewenden, diese erweitern, als auch selbst ständig grundlegende Ansätze implementieren.

Syllabus: 1. Einführung in Bayes'sche Optimierung
2. Surrogate Modelle
3. Acquisition Funktionen
4. Vollständige Bayes'sche Optimierung
5. Multi-fidelity Optimierung
5. Abschlussprojekt

Special Features: Teilnahmebeschränkung: 20 Personen.

Automated Machine Learning

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden lernen die grundlegenden Prinzipien von automatischen maschinellen Lernen (sowohl für traditionelles maschinelles Lernen, als auch für tiefes Lernen). Sie können Methoden der Hyperparameter-Optimierung und der neuronalen rchitektursuche erläutern, als auch auf neue Probleme anwenden. Insbesondere können sie diese Methoden praktisch anwenden, um damit die Performanz von Algorithmen für maschinelles Lernen auf feature-basierten Daten, Bilddaten als auch Daten für Zeitreihen zu optimieren.

Syllabus: 1. Design spaces in ML
2. Experimentation and visualization
3. Hyperparameter optimization (HPO)
4. Bayesian optimization
5. Other black-box techniques
6. Speeding up HPO with multi-fidelity optimization
7. Architecture search I + II
8. Meta-Learning
9. Dynamic Configuration
10. Beyond AutoML: algorithm configuration and control

Special Features: Für das Bestehen müssen als notwendige Bedingung Multiple-Choice Quizze (mind. 50% richtige Antworten) bestanden werden. Die Leistung kann entweder graduell pro Woche in der Vorlesung oder zum Ende des Vorlesungszeitraums als einmaliger schriftlicher Test erbracht werden.

Als Vorbereitung auf die mündliche Prüfung muss ein abschließendes Projekt bearbeitet werden.

Zuordnung zum Themenschwerpunkt Data Science.

Computability and Logic

Credits: 7

Offered in the following semesters: SS 2027

Lecturer: Vollmer (vollmer@thi.uni-hannover.de)

Learning Objectives: This module provides in-depth knowledge of the problems of computability and provability. Upon successful completion, students will understand the importance of mathematical logic for computer science. They will have gained an understanding of the possibilities and limitations of computability, formalizability and provability. They will analyse computational problems that arise in terms of their formalizability and solvability.

Syllabus:
In this lecture, we will deal with the question of which calculation problems can be solved algorithmically. Starting from the undecidability of the so-called halting problem, we will learn about different levels of algorithmic unsolvability. Particularly interesting statements arise from the field of mathematical logic; here we will deal in particular with Gödel's incompleteness theorems. Outline: Recursive enumerability, First-order predicate logic, Undecidability of first-order predicate logic, Proofs in first-order predicate logic, Arithmetic definability, Representability, Gödel's incompleteness theorem, The arithmetic hierarchy, Relative computability.

Computational Argumentation

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: Argumentation is an integral part of both professional and everyday communication. Whenever a topic or question is subject to controversy, people consider arguments to form opinions, to make decisions, or to convince others of a certain stance. In the last years, the computational analysis and synthesis of natural language argumentation has become an emerging research area, due to its importance for the next generation of web search engines and intelligent personal assistants. Based on statistical natural language processing techniques, computational argumentation covers the mining of arguments from natural language text, the assessment of stance argument quality, as well as the generation of new claims and arguments. The students learn both fundamentals from argumentation theory and state-of-the-art methods from computational argumentation. Assignments deepen the understanding of the methods.

Syllabus: Lecture parts: - Introduction to Computational Argumentation. - Basics of Natural Language Processing.
- Basics of Argumentation. - Argument Mining. - Argument Assessment. - Argument Generation. - Applications of Computational Argumentation. - Conclusion.

Special Features: Ideally, the lab "Argumentation Technology" is taken in parallel with this course.

Creation and Application of Knowledge Graphs

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Gottschalk, Karras (gottschalk@L3S.de; karras@l3s.de)

Learning Objectives: The students understand the topics and methodology for creating and applying knowledge graphs. This includes machine learning on and with knowledge graphs, data modeling, model mapping, data acquisition and transformation as well as applications that allow interaction with knowledge graphs. In addition, the students discuss on the combination of knowledge graphs with large language models.

Syllabus: This course will provide an understanding of topics and methodology for accessing, enriching and utilising the knowledge provided in knowledge graphs.
This is the preliminary course schedule:
Creation of Knowledge Graphs:
- Recap of Knowledge Graphs
- Knowledge Graph Extraction from Text
- Semantic Table Interpretation
- Knowledge Graph Construction Process
- Transforming Relational Databases to Knowledge Graphs
- Knowledge Graph Quality
- Knowledge Graph Analytics

Applications of Knowledge Graphs:
- Storytelling with Data
- Question Answering over Knowledge Graphs
- Machine Learning on Knowledge Graphs (Basics)
- Machine Learning on Knowledge Graphs (GNNs & Applications)
- Knowledge Ingestion into Large Language Models
- Real-world Knowledge Graphs

In the exercises, students will apply the learned methodology on example knowledge graphs.

Deep Learning Foundations

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Sikdar (sandipan.sikdar@l3s.de)

Learning Objectives: Students learn and implement state-of-the-art deep neural network architectures.

Syllabus: Tentative plan: Machine learning basics, Neural networks, generative models, Generative adversarial networks, Variational autoencoders, Diffusion models, Normalizing flow, Neural ODE.

Special Features: Dieses Modul ist Bestandteil der Leibniz AI-Academy. Weitere Informationen auf https://www.ai-academy.uni-hannover.de/de/.

Digital Image Processing

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Ostermann (ostermann@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden kennen zweidimensionale diskrete Systeme, Abtastung, die Grundlagen der visuellen Wahrnehmung, diskrete Geometrie, die Bildrestauration, die Bildbearbeitung sowie die Bildanalyse.

Syllabus: - Grundlagen
- Lineare Systemtheorie
- Bildbeschreibung
- Diskrete Geometrie
- Farbe und Textur
- Transformationen
- Bildbearbeitung
- Bildrestauration
- Bildcodierung
- Bildanalyse

Special Features: Zu der Veranstaltung gehört ein Labor, das bestanden werden muss. Die Vorlesung wird auf Englisch gehalten, Vorlesungsunterlagen sind auf Deutsch erhältlich!

Distributed Real-time Systems

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Rizk (amr.rizk@ikt.uni-hannover.de)

Learning Objectives: At the end of the course, students have an understanding of the intersection of communication technology and distributed real-time control. Specifically, students will learn: The goals and the techniques for the analysis of consensus and synchronization in multi-agent distributed and networked systems, as well as, the design of communication structures for networked controllers.

Syllabus: ■Motivation for distributed real-time systems and networked control
■Basics of algebraic Graph Theory
■Consensus in Multi-agent systems, continuous time / discrete time consensus, consensus over switching networks, special cases: leader-follower systems
■Synchronization of Multi-agent systems, asymptotic results, synchronization for identical and non-identical agents, synchronizing networks
■Design of communication structures for distributed real-time systems, Delay measures, Examples including Cooperative Adaptive Cruise Control

Efficient Algorithms

Credits: 7

Offered in the following semesters: WS 2025/26

Lecturer: Meier (meier@thi.uni-hannover.de)

Learning Objectives: Students are familiar with selected combinatorial problems and efficient methods for solving them. They are able to synthesise and analyse such algorithms.

Syllabus: Shortest paths,Maximum flows,Matchings,Amortised runtime analysis,Union-find data structure,Energy complexity,Matroids and greedy algorithms,Linear programming,The primal-dual method,Streaming algorithms,Matrix multiplication,Parallel algorithms.

Federated Learning

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Fisichella (mfisichella@l3s.de)

Learning Objectives: Federated Learning is an innovative approach for training machine learning models on decentralised devices while keeping the data localised. It enables collaborative model training without the need to centralise sensitive data, making it particularly valuable for privacy-sensitive applications such as healthcare, finance and mobile devices. In this course, we will explore the basics of federated learning, its key concepts, applications and challenges.
The aim is to compare traditional machine learning vs. federated learning and understand the differences between traditional centralised machine learning and federated learning. The course explores also the benefits and challenges of federated learning compared to centralised approaches.

Syllabus: The lectures will introduce the topic and federated application. During the exercises students will experiment on how to run a FL application.

Formal Languages

Credits: 7

Offered in the following semesters: SS 2027

Lecturer: Meier (meier@thi.uni-hannover.de)

Learning Objectives:
The module provides in-depth knowledge of formal languages.
Students analyse phenomena from the theory of formal languages beyond the content of the introductory lectures. They construct various types of automata and grammar models for regular and context-free languages.
They evaluate common transformations and other procedures for these models.
They evaluate the possibilities for applications in syntax analysis. They understand the relevant (un)decidability results and are able to transfer them to related problems.

Syllabus:
Regular and context-free languages play an extremely important role in compiler construction and other disciplines of computer science. The lecture focuses on these two language classes and examines their properties.

Outline:

Regular languages:
Finite automata,
Myhill-Nerode theorem,
Minimal automata,
Automata and semigroups.

Context-free languages:
Chomsky normal form and CYK algorithm,
Greibach normal form and cellar automata,
Deterministic context-free languages,
Decidability questions.

Context-sensitive languages and type 0 languages.

Foundations of Information Retrieval

Credits: 5

Offered in the following semesters: WS 2025/26

Lecturer: Nejdl (nejdl@kbs.uni-hannover.de)

Learning Objectives: Die Studierenden kennen grundlegende Algorithmen und Technologien des Information Retrieval für Dokumentsammlungen und das Web, haben sie diskutiert, und können sie anwenden.

Syllabus: Grundlegende Algorithmen und Technologien für das Web, insbesondere:
IR-Systeme: Indizierung, Anfragebeantwortung, Evaluierung, Text Klassifikation und Clustering; World Wide Web: Aufbau, Struktur und Analyse, Web-Crawling, Suche, Pagerank-Algorithmen; sowie weitere dazu passende ausgewählte Kapitel.

Graph Signal Processing

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Rizk (amr.rizk@ikt.uni-hannover.de)

Learning Objectives: The goal of this lecture is that the students:
- understand the basics of Graph Signal representation and processing based on spectral graph theory
- have an overview and technical depth of some methods for graph filtering and sampling
- are able to apply GSP methods to a range of areas including the analysis of distributed sensor networks and point clouds

Syllabus: - Short introduction to graph signals and node domain processing
- Node domain graph filters
- Graph Fourier Transform, Filtering, Application of GFT to common operators, Graph Spectra
- Graph Signal models, node domain sampling, frequency domain sampling, Conditions for reconstruction
- Robust Graph spectral sampling
- Applications to domains such as transportation networks, sensor networks, point clouds, and learning with Graph Signals

Hardware-accelerated Communication Systems

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Rizk (amr.rizk@ikt.uni-hannover.de)

Learning Objectives: The goal of this lecture is that the students
- understand the basics of hardware acceleration of protocol-based communication systems and its applications
- have an overview of methods for domain specific programming for the communication control plane and the communication data plane
- recognize possible applications of virtualization in communication systems
- are able to implement communication data processing applications in a hardware-near domain specific language that can be synthesized to communication hardware platforms

Syllabus: Hardware Architectures and abstractions for the hardware-acceleration of protocol-based communication systems, interfaces, hardware-near domain specific language (e.g. p4), Offloading applications to the data plane, kernel-bypass, virtualization of communication systems, Verification approaches to hardware programs for communication systems.

Special Features: Some of the taught concepts will be implemented in the exercise using the taught domain specific language.

Image Analysis I

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Rottensteiner (rottensteiner@ipi.uni-hannover.de)

Learning Objectives: Die Studierenden lernen Strategien und Methoden zur automatischen Erkennung und Rekonstruktion von Objekten aus digitalen Bildern auf Grundlage von Verfahren des maschinellen Lernens kennen. Sie sind anschließend in der Lage, probabilistische Klassifikationsmethoden sowie Verfahren des Deep Learning erfolgreich umzusetzen und auf verschiedene Probleme anzuwenden.

Syllabus: Strategien der automatischen Bildanalyse;
Sensoren für die Datenerfassung;
Ableitung von Merkmalen aus Sensordaten, Texturanalyse;
Statistische Methoden der Mustererkennung;
Generative probabilistische Klassifikatoren, Bayes-Klassifikation;
Theorie von Dempster-Shafer;
Neuronale Netze, Deep Learning;
Anwendungen des Deep Learning;
Domänenadaption, Lernen unter Label Noise.

Special Features: Die Vorlesung wird auf Englisch gehalten, falls sie von Studierenden des englischsprachigen Masterstudiengangs "Geodesy and Geoinformatics" belegt wird und diese es wünschen. Andernfalls ist die Sprache der Vorlesung Deutsch. Die Prüfung wird auf Deutsch abgenommen, wenn nicht vom Studierenden Englisch als Prüfungssprache gewünscht wird.

Image Analysis II

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Rottensteiner (rottensteiner@ipi.uni-hannover.de)

Learning Objectives: Die Studierenden lernen Verfahren der nichtsemantischen Segmentierung ebenso kennen wie nichtprobabilistische Verfahren des maschinellen Lernens und Verfahren zur kontextbasierten Klassifikation auf Grundlage von graphischen Modellen. Sie sind anschließend in der Lage, die besprochenen Verfahren erfolgreich umzusetzen und auf verschiedene Probleme anzuwenden.

Syllabus: Strategien der automatischen Bildanalyse;
Skalenraum;
Interestoperatoren, Kantenextraktion;
Regionenbasierte Segmentierung inklusive graphenbasierter Methoden;
Snakes;
Modelle in der Bildanalyse;
Nichtprobabilistische Klassifikatioren: Support Vector Machines, Boosting, Random Forests;
Graphische Modelle: Bayes-Netze, Markov-Zufallsfelder, Conditional Random Fields.

Special Features: Die Vorlesung wird auf Englisch gehalten, falls sie von Studierenden des englischsprachigen Masterstudiengangs "Geodesy and Geoinformatics" belegt wird und diese es wünschen. Andernfalls ist die Sprache der Vorlesung Deutsch. Die Prüfung wird auf Deutsch abgenommen, wenn nicht vom Studierenden Englisch als Prüfungssprache gewünscht wird.

Image Sequence Analysis

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Mehltretter (mehltretter@ipi.uni-hannover.de)

Learning Objectives: At the end of the course, students have a good insight into the goals, tasks and methods of image sequence analysis. They are able to evaluate monoscopic and stereoscopic image sequences with regard to 3D geometry and content and know the limits of the automatic methods used for this purpose: foreground/background separation, optical flow as well as object tracking etc. They are also able to integrate motion models into the evaluation, for example on the basis of Kalman filter, EKF; particle filters are also known in principle. In individual areas, the students have exemplary detailed knowledge, e.g. in the area of tracking-by-detection and data association. As a basis for further Master's studies, the students should develop their analytical and transfer skills through exercises, also from current research projects.

Syllabus: Introduction; sensors for capturing image sequences; short repetition Image processing; process chain for evaluating image sequences; foreground/background separation; optical flow; object detection and tracking; motion models and filtering

Interpretable Machine Learning

Credits: 5

Offered in the following semesters: WS 2025/26

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden verfügen über Kenntnisse der theoretischen als auch praktischen Grundlagen des interpretierbaren maschinellen Lernens (iML). Sie verstehen die mathematischen Grundlagen und können iML-Ansätze implementieren, ausführen und auswerten. In einen abschließenden Projekt haben die Studierenden gelernt, wie sie die Konzepte, die sie in der Vorlesung gelernt haben, selbstständig auf eine neue Problemstellung anwenden können.

Syllabus: Der voraussichtliche Plan umfasst: 1. Introduction, 2. GAMs and Rule-based Approaches, 3. Feature Effects, 4. Local Explanations, 5. Shapley Values for Explainability, 6. Instance-wise Feature Selection, 7.+8. Gradient-based Feature Attribution, 9. Evaluating Interpretability and Utility, 11. Conclusion

Special Features: Zuordnung zum Themenschwerpunkt Data Science.

Introduction to Natural Language Processing

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: The students have basic skills needed to tackle analysis and generation tasks in natural language processing (NLP) with knowledge-based methods. Starting from fundamentals of linguistics and empirical methods, they have learned rule-based and basic statistical techniques. The application of these techniques they have master for fundamental NLP tasks, including text segmentation, syntactic parsing, and entity recognition. Students learn to design, implement, and evaluate respective NLP methods, both theoretically and in practical assignments. Besides the topical content, the students have learned how to conduct data-driven scientific experiments.

Syllabus: Lecture parts: Overview of Natural Language Processing. Basics of Linguistics. NLP using Rules. NLP using Lexicons. Basics of Empirical Methods. NLP using Regular Expressions. NLP using Context-Free Grammars. NLP using Language Models. Practical Issues.

Special Features: The home assignments will include both programming and pencil-and-paper tasks.

Knowledge Engineering and Semantic Web

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Auer, Stocker (markus.stocker@tib.eu; soeren.auer@tib.eu)

Learning Objectives: Understanding of basic knowledge engineering principles, such as ontologies & knowledge graphs, reasoning, inference. Theoretical and practical understanding and experience of established W3C standards for data sharing (RDF, SPARQL, RDFa, Microdata) and established Semantic Web technologies. Ability to understand, interpret and design knowledge models and ontologies.

Syllabus: This course will provide an introduction to fundamental knowledge engineering principles as well as practical knowledge and insights into the use and application of state-of-the-art Semantic Web technologies. Based on established W3C standards such as RDF/OWL, Semantic Web technologies, Linked Data or semantic markup (through RDFa and Microformats) enable the application of formal knowledge engineering principles on the Web and have emerged as defacto standards for (a) sharing data on the Web and (b) for annotating unstructured Web documents with entity-centric knowledge. The wider goal and purpose is to improve understanding and interpretation of Web documents and data, for instance, to facilitate Web search or data reuse. This course will introduce key concepts of Knowledge Engineering and their application specifically in the context of the Web. Key areas include knowledge representation and reasoning, knowledge & information extraction and knowledge retrieval, for instance, through state of the art semantic search and entity-retrieval approaches.

1. Course Introduction & Overview

2. Semantic Web Principles - URIs and RDF

3. RDF & RDFS

4. SPARQL is not just a Query Language

5. Ontologies & Logic

6. Description Logics

7. OWL-Web Ontology Language

8. Linked Data and Knowledge Graphs

9. OWL & Rules, Ontology Engineering

10. Ontology Learning & Knowledge Extraction

11. Linked Data & Semantic Search

12. Embedded Entity Markup: RDFa, Microdata, Microformats

Special Features: Zuordnung zum Themenschwerpunkt Data Science.

Computational Complexity

Credits: 7

Offered in the following semesters: WS 2025/26

Lecturer: Vollmer (vollmer@thi.uni-hannover.de)

Learning Objectives: The module provides in-depth knowledge of concepts, techniques and phenomena of complexity theory. Upon successful completion, students will be able to analyse algorithmic problems with regard to various aspects of complexity. They will evaluate the consequences of completeness results. They will develop complexity classifications for new algorithmic problems. They will study current research literature, summarise it in writing and present it orally.

Syllabus: - The polynomial time hierarchy- Probabilistic complexity classes- Counting classes- Toda's theorem- Isomorphism of complete sets (Berman-Hartmanis conjecture)- Thin complete sets and advice classes (Karp-Lipton theorem)- Relativisations (Baker-Gill-Solovay theorem)- Interactive proof systems

Cryptography

Credits: 7

Offered in the following semesters: WS 2026/27

Lecturer: Meier (meier@thi.uni-hannover.de)

Learning Objectives:
Students will have in-depth knowledge of the most important cryptographic methods and protocols. After successfully completing the course, students will be able to evaluate common methods in terms of correctness and security. They will develop new cryptographic primitives. Participants learn to understand common procedures from practice and acquire security-critical analysis skills with regard to cryptographic procedures.

Syllabus:
The lecture covers classic methods in cryptography (Caesar, substitution, polyalphabetic ciphers) and also addresses weaknesses and security concepts. It then goes on to look at perfect security and Shannon's theorem. The AES cryptosystem is analysed. The concept of public-key encryption is then explained using RSA. The Diffie-Hellman key exchange protocol is used as an example to explain the secret exchange of keys. Current topics such as the McEliece cryptosystem, bitcoins, post-quantum cryptography and zero-knowledge proofs are also discussed.

Artificial Intelligence I

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Gottschalk (gottschalk@L3S.de)

Learning Objectives: The students have learned the basics of modern Artificial Intelligence (AI) and some of its most representative applications.

Syllabus: i) Introduction to AI ii) Constraint Satisfaction Problems iii) Problem solving by searching iv) Markov Decision Processes v) Reinforcement Learning.

Artificial Intelligence II

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Nejdl (nejdl@kbs.uni-hannover.de)

Learning Objectives: The students know the basics of modern artificial intelligence (AI) and some of their most important ones
representative applications, building on what they have learned in Artificial Intelligence (I).

Syllabus: i) Bayesian Networks ii) Hidden Markov Models iii) Machine Learning iv) Advanced Topics of AI

Lab: Argumentation Technology

Credits: 6

Offered in the following semesters: SS 2025

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: This lab deepens the practical understanding of the contents of the course "Computational Argumentation". Starting from existing natural language processing libraries includes the development, implementation, and evaluation of sophisticated computational approaches to a number of common tasks related to the analysis and synthesis of human arguments. As such, this lab exemplifies the whole spectrum of typical natural language processing techniques in a domain from state-of-the-art research.

Syllabus: - Recap of general python progamming concept. - Task on argument acquisition. - Task on argument mining. - Task on argument assessment. - Task on argument generation.

Special Features: This lab should ideally be taken in parallel with the master's course "Computational Argumentation". The maximum number of participants is 30.

Lab: Human Language Technology

Credits: 6

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: This lab deepens the practical understanding of the content of the Statistical Natural Language Processing course. Starting from existing natural language processing libraries, students learn to develop, implement, and evaluate sophisticated computational approaches to a range of common tasks related to natural language analysis and synthesis. They will be familiar with the full spectrum of typical statistical natural language processing techniques in a variety of common tasks.

Syllabus: Recap of general python programming concepts, task on clustering, task on classification, task on sequence labeling, task on neural networks and transformers

Special Features: This lab should ideally be taken in parallel with the master's course "Statistical Natural Language Processing". The maximum number of participants is 30.

Laboratory Reborn Articles

Credits: 6

Offered in the following semesters: SS 2025, WS 2025/26

Lecturer: Stocker (markus.stocker@tib.eu)

Learning Objectives: Students will learn about the Open Research Knowledge Graph (ORKG, https://orkg.org) platform for scientific knowledge management developed by Technische Informationsbibliothek (TIB) and Leibniz University Hannover, and learn and apply its reborn articles technique for the efficient publication of research findings as open, reproducible, and machine-processable (born-reusable) research data. Students will also learn how such data can be utilized in research for machine-assisted scientific knowledge integration and synthesis. As a result, students will understand the importance of advanced knowledge management to modern research.

Syllabus: The laboratory will first introduce students to the Open Research Knowledge Graph and reborn articles (see suggested literature below for more information), and explain the role of the approach in the production and publication of machine-readable scientific knowledge as well as the machine-assisted reuse of scientific knowledge. Subsequently, participants will apply the technique to articles authored by research staff at selected university institutes or, if applicable, also to articles the students have co-authored themselves. Finally, the laboratory will showcase how machine-assisted use of scientific knowledge can support advanced knowledge presentation (visualization) and knowledge synthesis in research.

Special Features: This is an interdisciplinary laboratory open to interested students from all institutes and faculties. Ideally, the research conducted at the respective institute is supported by data analysis implemented in Python or R and the findings published in related articles are (primarily) quantitative (statistical) data. The laboratory is limited to maximally 15-16 students.

Laserscanning

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Brenner (claus.brenner@ikg.uni-hannover.de)

Learning Objectives: This lecture imparts the basic principles about laser scanning and its respective application areas.
After successful completion of the lecture, students are able to explain and apply selected techniques and algorithms for the low-, intermediate- and high-lever processing of laser scanning data.

Syllabus: Airborne, terrestrial and mobile mapping laser scanning: scan geometry and technical characteristics. Low-, intermediate and high-level tasks. Representation of 3D rotations: matrix, angles, axis and angle, quaternions. Estimation of similarity transforms and the iterative closest point algorithm. Estimation and segmentation of lines and planes. Region growing, RANSAC and MSAC, Hough transform, scanline grouping. Scanning and segmentation in robotics applications. Decision trees and random forests for point cloud classification. Markov chains and Markov chain Monte Carlo methods and their use for high-level interpretation. In the exercises, selected algorithms will be programmed.

Special Features: exercises are part of the exam

Advanced Logics

Credits: 7

Offered in the following semesters: SS 2026

Lecturer: Meier (meier@thi.uni-hannover.de)

Learning Objectives:
The module provides in-depth knowledge of complexity issues in logical calculi. Upon successful completion of the course, students will be able to evaluate logical calculi with regard to complexity issues. They will be able to analyse logical characterisations of complexity classes and design classifications with regard to the Boolean function domain.

Syllabus:
Modal logic, frames, properties of frames, Ladner's algorithm, Post's lattice, classification of the modal satisfiability problem, satisfiability and model checking for temporal logic and hybrid logics, dependence logic, constraint satisfaction problems, Schaefer's dichotomy theorem, Feder-Vardi dichotomy theorem

Methods of User Authentication

Credits: 3

Offered in the following semesters: WS 2025/26

Lecturer: Golla (fahl@sec.uni-hannover.de)

Learning Objectives: Students gain an in-depth understanding of security and usability challenges in user authentication. They are familiar with core concepts from cryptography, protocol design, usability engineering, and Web standardization. Students are able to critically analyze real-world authentication schemes and assess their security, usability, and deployability. By the end of the course, students can advocate for and apply modern, user-centered authentication methods grounded in empirical findings and sound security principles.

Syllabus: The lecture begins by differentiating authentication from authorization before examining password-based authentication, its weaknesses, and reinforcement strategies, including hashing, strength metrics, and common attacks like credential stuffing and phishing. It then covers defenses such as password managers, two-factor authentication, risk-based authentication, breach alerts, and security warnings. Students will also explore PAKEs, challenge-response protocols, biases in graphical passwords, and mobile authentication security (e.g., PINs). The course concludes with analyzing password alternatives like biometrics and hardware tokens, leading to an in-depth evaluation of modern passwordless authentication, such as passkeys, and the security-usability trade-offs in authentication design. Please note that some topics listed below will take more than one lecture session:1. Introduction: Overview, Definitions, UDS Criteria2. Knowledge-Based Authentication- PINs and Passwords- Hashing, Guessing, Strength Metrics- Attacks and Threat Models- Authentication Protocols (PAKEs, SSO)- Reinforcement (MFA, RBA, and Warnings)- Password Managers- Fallback Authentication- Graphical Passwords3. Biometry-Based Authentication- Face and Fingerprint Recognition- Behavioral Biometrics, Multimodal Systems, Privacy Aspects4. Token-Based Authentication- Hardware Security Keys, Smartcards, and Phones- Passwordless Authentication (Passkeys and FIDO)5. Misc- Implicit and Continuous Authentication- Evaluation of Authentication Schemes- Accessibility- Case Studies

Mobile Interaction

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Rohs (michael.rohs@hci.uni-hannover.de)

Learning Objectives: Kenntnis der Besonderheiten der mobilen Mensch-Computer-Interaktion. Kenntnis von Interaktionstechniken für mobile Geräte unter der Verwendung von Touchscreen-Gesten, Bewegungs-Gesten und Kamera. Verarbeitung von Kontextinformationen.

Syllabus: In dieser Vorlesung werden die Besonderheiten der mobilen Mensch-Computer-Interaktion, wie Aufenthaltsort und Einfluss von Umgebungsfaktoren, behandelt. Es werden mobile Betriebssysteme und Plattformen vorgestellt (z.B. Android und iOS). Android wird detaillierter dargestellt, so dass Programmieraufgaben mit mobilen Geräten durchgeführt werden können. Die behandelten Themen umfassen mobile Ein- und Ausgabetechnologien (z.B. Touchscreens), Multimodalität (visuell, auditiv, haptisch), Ortsabhängigkeit und Kontext, Fußgängernavigation, drahtlose Kommunikation, Szenarien und Evaluation im mobilen Kontext, Visualisierung und Interaktionstechniken für kleine Displays, Kamera- und Sensor-basierte mobile Interaktion, Touchscreen-Gesten, Bewegungs-Gesten, sowie Anwendungskategorien und Entwurfsmuster. Der Übungsteil umfasst Programmieraufgaben, die Entwicklung von mobilen Nutzungsszenarien mit Papier-Prototypen, die Verarbeitung von Touchscreen-Gesten, sowie die Evaluation im mobilen Kontext.

Special Features: Zuordnung zum Themenschwerpunkt Human-Centered Computing.

Multi-Agent Communication Systems

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Tahir, Rizk (amr.rizk@ikt.uni-hannover.de; anam.tahir@ikt.uni-hannover.de)

Learning Objectives: This course begins with an overview of various controlled communication systems, establishing a foundation in the principles and challenges of such systems. Then it introduces the general framework of Markov Decision Processes (MDPs) and their extension to Partially Observable Markov Decision Processes (POMDPs), offering applications of decision-making in uncertain communication environments.
In this lecture the students learn to model communication systems as MDPs or POMDPs, which enables structured analysis and optimization of system performance under different conditions. Building on this, the course introduces practical reinforcement learning techniques tailored for solving/applying (PO)MDPs in communication systems. The focus is initially on single-agent systems and later progresses to multi-agent communication systems, where interactions between agents introduce additional complexity. Students will learn how RL can be extended to manage and optimize these interactions, with a focus on both cooperative and competitive strategies.

Syllabus: ■Introduction to the relevant classes of communication systems
■Introduction to MDPs and POMDPs
■Modelling of communication systems as (PO)MDP
■Introduction to Reinforcement learning for communication System (PO)MDPs
■Learning in single-agent communication systems
■Approaches to multi-agent communication systems (exact, decompositional, approximative)
■Learning in multi-agent communication systems
■Cooperative vs competitive communication system modelling

Multi-Agent Interactions and Games

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Kudenko (kudenko@l3s.de)

Learning Objectives: 1. The students master the mathematical foundations of multi-agent interactions using games as a formal model.
2. They know algorithms for distributed problem solving.
3. They have developed an understanding of the complexities of coordination and competition.

Syllabus: 1. Game Theory (Mathematical definition of games and rational behaviour, games under uncertainty, repeated games.
2. Algorithms to compute optimal behaviour (Alpha-Beta and extenstions, Monte Carlo Tree Search).
3. Modes of Interaction (Communication, Negotiation and Bargaining, Argumentation).
4. Mechanism Design.
5. Multi-agent Learning .

Production of Optoelectronic Systems

Credits: 5

Offered in the following semesters: WS 2025/26

Lecturer: Overmeyer (ludger.overmeyer@ita.uni-hannover.de)

Learning Objectives: Qualifikationsziele: Das Modul vermittelt grundlegende Kenntnisse über Prozesse und Anlagen, die bei der Herstellung von Halbleiterbauelementen und Mikrosystemen eingesetzt werden. Der Fokus liegt auf dem "back-end process", also der Fertigung ab dem Vereinzeln von Wafern. Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage,
- die Begriffe optoelektronsische Systeme, Waferherstellung, Front-End und Back-End fachlich korrekt einzuordnen und die Fertigungsprozessen von Halbleiterbauelementen überblicksartig wiederzugeben,
- ausgehend vom Rohstoff Sand die Fertigungsschritte inhaltlich zu erläutern sowie prozessrelevante Parameter abzuschätzen,
- verschiedene Aufbau- und Verbindungstechniken grafisch zu veranschaulichen und physikalische Grundlagen der Verbindungstechnik zu erläutern,
- unterschiedliche Gehäuseformen anwendungsbezogen auszuwählen und zu klassifizieren.

Syllabus: - Waferfertigung und Strukturierung
- Mechanische Waferbearbeitung
- Mechanische Chipverbindungstechniken (Mikrokleben, Löten, Eutektisches Bonden)
- Elektrische Kontaktierverfahren (Wirebonden, Flip-Chip-Bonding, TAB);
- Gehäusebauformen der Halbleitertechnik
- Testen und Markieren von Bauelementen
- Aufbau und Herstellung von Schaltungsträgern
- Leiterplattenbestückungs
- und Löttechniken

ASIPLab: Design of Application-Specific Instruction-Set Processors

Credits: 6

Offered in the following semesters: SS 2025

Lecturer: Blume (blume@ims.uni-hannover.de)

Learning Objectives: Das Labor vermittelt die Konzepte und Architekturen spezialisierter Prozessoren, die zugrungeliegenden theoretischen Ansätze sowie die Beschleunigung von Systemen durch die Architekturanpassung am Beispiel des Cadence LX7 Prozessors.

Qualifikationsziele:
Nach erfolgreicher Absolvierung des Moduls sind die Studierenden in der Lage,
- das Konzept der anwendungsspezifischen Prozessoren zu verstehen und anzuwenden
- eine Basisprozessorarchitektur für eine Beispielanwendung aus dem Bereich der Fahrerassistenzsysteme zu spezialisieren
- die Architektur für verschiedene Optimierungsziele (z.B. maximale Rechenleistung oder minimale Verlustleistungsaufnahme) zu evaluieren und zu bewerten

Syllabus: Modulinhalte:
- Architekturprinzipien von Prozessoren und ihre Spezialisierungsmöglichkeiten. Definitionen von anwendungsspezifischen Instruktionssatzprozessoren wie z.B. die der LX7-Prozessorarchitektur und ihrer Erweiterungsmöglichkeiten.
- Neuartige Erweiterungen des Instruktionssatzes unter Verwendung des Cadence Xtensa Xplorers bzw. des Cadence LX7 Prozessors.
- Hardwarebeschreibungssprache „Tensilica Instruction Extension“
- Verifikation und Emulation von Prozessorarchitekturen

Special Features: Anmeldung zum Labor unter https://www.tnt.uni-hannover.de/etinflabor/.

Zuordnung zum Themenschwerpunkt Systemnahe Informatik.

Project: Ethical Artificial Intelligence

Credits: 6

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: Artificial intelligence (AI) in general and natural language processing (NLP) in particular are often used in real-world scenarios involving sensitive data about humans. The decisions and behavior of the respective AI systems can therefore have ethical consequences, for example potentially unfair treatment in connection with potentially unfair treatment of individuals or groups of people.
In this project, the students acquire a deeper practical understanding of statistical methods from AI and NLP for ethically sensitive problems, such as the analysis and mitigation of social bias and media bias as well as the computational generation of argumentative and explanatory texts.
Participants team-up in small groups that collaboratively develop, implement, and evaluate NLP methods and tool. They learn how to work towards more ethical AI systems in real scenarios, as well as to present and discuss the solutions they develop.

Syllabus: Recap of general python programming concepts; sophisticated development and evaluation tasks on NLP methods and tools to ethical-AI problems.
- In between, introduction and discussion of the problems.

Special Features: The maximum number of participants is 30.

Project: Machine Learning

Credits: 6

Offered in the following semesters: SS 2025, WS 2024/25, WS 2025/26

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden können ihre theoretischen Kenntnisse des maschinellen Lernens in all seinen Facetten (ML, DL, iML, RL, AutoML) auf eine praktische Anwendung mit einer verbundenen Forschungsfrage übertragen. Sie haben dadurch sowohl ihre Fähigkeiten im Wissenstransfer als auch in der Umsetzung gestärkt. Des Weiteren haben sie alle notwendigen Fähigkeiten (Vorträge, Berichte, sauberes wissenschaftliches Arbeiten) zur Vorbereitung einer Masterarbeit im Bereich ML erworben.

Syllabus: Nach einer Einarbeitung in die spezifische Fragestellung (die für jeden Studierenden oder Gruppe individuell festgelegt wird) über das Studieren von wissenschaftlichen Arbeiten werden die praktischen Ziele definiert und erste praktische Ansätze für gegebene Benchmarks implementiert und systematisch ausgewertet. Am Ende wird eine Abschlusspräsentation gehalten und eine entsprechende schriftliche Arbeit mit allen Ansätzen und Ergebnissen eingereicht.

Special Features: Teilnahmebegrenzung: 20

Project: Reinforcement Learning

Credits: 6

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden sind in der Lage, Reinforcement Learning praktisch anzuwenden. Dazu haben Sie gelernt, ein umfangreiches Projekt zu planen, als Team auszuführen und aktuelle Forschungsergebnisse in die Praxis zu bringen. Insbesondere heißt das:- Konzipieren einer eigenen Aufgabe für einen physischen Roboter in der zugehörigen Simulation. Die Aufgabe sollte lösbar, kreativ and gesellschaftlich sinnvoll sein.- Erarbeiten eines Ansatzes zum Trainieren von RL Agenten für diese Aufgabe mit standard RL Software für bestmögliche Lösung der Aufgabe und sicheren Transfer auf einen echten Roboter- Umsetzung einer Ansteuerung eines Roboters mit Python und/oder ROS, so dass die Agenten der Simulation auf den physischen Roboter übertragen werden können- Entwickeln einer physischen Testumgebung. Diese soll die modellierte Aufgabe so gut wie möglich widerspiegeln und gleichzeit den gesellschaftlichen Nutzen demonstrieren.- Evaluieren des Gesamterfolges des Projektes anhand der Aufgabenstellung.- Koordinieren des Teams durch gemeinschaftliches Projektmanagement, so dass Aufgaben und Zeit fair verteilt und zuverlässig ausgeführt werden.

Syllabus: Grundlagen der Robotik, Sim2Real transfer in Reinforcement Learning, Modellierung von Robotikanwendungen

Special Features: Teilnahmebeschränkung: 25 (wegen verfügbarer Hardware und Raumgröße)

Quantum Computing

Credits: 7

Offered in the following semesters: WS 2025/26

Lecturer: Egly (r.kluge@thi.uni-hannover.de)

Learning Objectives: After successful completion of the course, students are able to illustrate, describe, and evaluate the foundational and central concepts in quantum computing (including the corresponding complexity theory). Moreover, students are able to prove the correctness of (simple) quantum algorithms and implement them using the quantum circuit model.

Syllabus: Quantum Computing: • Basic notions (including mathematical and quantum-mechanical background, gates) • Programming techniques and reverse computation • Simple quantum algorithms like Deutsch, Deutsch-Jozsa, Bernstein-Vazirani, quantum teleportation • Algorithm of Grover • Algorithm of Simon • Quantum Fourier transformation, phase estimation, and order finding • Algorithm of Shor • Hamiltonian simulation • The HHL algorithm to solve systems of linear equations Quantum Complexity Theory • Review: Probabilistic complexity classes (like BPP and PP) • Uniform classes of Boolean and quantum circuits, • The extended Church-Turing thesis and quantum computing • BQP (robustness, relation to other classes, examples) • QMA (= quantum Merlin-Arthur, “quantum NP”) • Quantum query complexity

Quantum Computing

Credits: 7

Offered in the following semesters: WS 2025/26, WS 2026/27

Lecturer: Abc

Learning Objectives: After successful completion of the course, students are able to illustrate, describe, and evaluate the foundational and central concepts in quantum computing (including the corresponding complexity theory). Moreover, students are able to prove the correctness of (simple) quantum algorithms and implement them using the quantum circuit model.

Syllabus: Quantum Computing:
- Basic notions (including mathematical and quantum-mechanical background, gates)
- Programming techniques and reverse computation
- Simple quantum algorithms like Deutsch, Deutsch-Jozsa, Bernstein-Vazirani, quantum teleportation
- Algorithm of Grover
- Algorithm of Simon
- Quantum Fourier transformation, phase estimation, and order finding
- Algorithm of Shor
- Hamiltonian simulation
- The HHL algorithm to solve systems of linear equations

Quantum Complexity Theory
- Review: Probabilistic complexity classes (like BPP and PP)
- Uniform classes of Boolean and quantum circuits,
- The extended Church-Turing thesis and quantum computing
- BQP (robustness, relation to other classes, examples)
- QMA (= quantum Merlin-Arthur, “quantum NP”)
- Quantum query complexity

Quantum Information Processing

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Hirche (hirche@tnt.uni-hannover.de)

Learning Objectives: Students will understand the basic concepts of quantum information processing. In particular, they will have a broad overview of the tools needed to dive deeper into topics such as quantum computing, quantum information theory and quantum machine learning. The focus will be on theoretical considerations of what we can achieve with quantum computing hardware and understanding the differences to traditional information processing. To achieve this, students will also solidify and widen their knowledge in mathematical tools, in particular linear algebra. At the end of the course students will be able to understand and explain current research in the field and independently solve problems related to it.

Syllabus: Quantum states, quantum channels, density matrix formalism, measurements; no-cloning theorem; distance measures; quantum circuits; quantum algorithms: quantum teleportation, super dense coding, Fourier transform, Shor's factoring algorithm; Grover's search algorithm; noisy quantum circuits, bounds from information theory; Entanglement and non-Locality, uncertainty relations; quantum error-correction; quantum machine learning.

Reinforcement Learning

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Die Studierenden haben sich sowohl die theoretischen als auch praktischen Grundlagen des Reinforcement Learning angeeignet. Sie haben dazu sowohl die mathematischen Grundlagen verinnerlichen, als auch die Fähigkeit, RL-Agenten zu implementieren, trainiern und ausgewerten zu können, erlangt. In einen abschließenden Projekt haben die Studierenden gelernt, wie sie die Konzepte, die sie in der Vorlesung erlernt haben, selbstständig auf eine neue Problemstellung anwenden können.

Syllabus: 1. Markov-Decision Processes and Variants
2. Online Reinforcement Learning
3. Deep Q-Learning
4. Policy Search
5. Policy Gradient
6. Actor-Critic Approaches
7. Exploration
8. Model-based RL
9. Benchmarking and Scientific Standards
10. Automated RL
11. Generalization

Special Features: Teilnahmebeschränkung: 40. Bitte erkundigen Sie sich im Fachgebiet nach dem Teilnahmeverfahren. Es müssen 50% der Quizpunkte entweder in den Sessions oder am Ende des Semesters bestanden werden, um zum Projekt zu gelassen zu werden.

Research Methods for Autonomous and Intelligent Systems

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Navarro (nicolas.navarro@l3s.de)

Learning Objectives: This course is designed to teach participants some essential tools for working with scientific literature and material (in machine learning and robot learning). This includes learning how to search for scientific material, how to read and evaluate papers, how to do a literature search, how to write scientifically, and how to present scientific work.
The course consists of introductory talks/lectures and hands-on practical work by writing a short paper (max. six pages excluding references) on a chosen topic under the broad umbrella term "Autonomous and Intelligent Systems". The topics will be provided by a supervisor who advises them during the semester. At the semester's midpoint, each participant will submit an ungraded first draft of their paper, for which they will receive detailed feedback from their supervisor. At the end of the semester, the final graded paper has to be submitted and presented during the conclusion meeting. The course considers the use of generative AI (https://luhki.uni-hannover.de/) as a helping tool. However, we will emphasize critical thinking and foster students' own writing ability.

Syllabus: Organization and Introduction.
Research Question and Hypothesis.
Experimental Design.
Evaluation Design.
Research Paper / Thesis Structure.
How to write a literature review / background section, including how to scan/read papers.
How to write a methods section.
How to write a results section including results presentation (figures, tables, etc.).
How to write a discussion, conclusion and future work section/chapter.
How to write an introduction and abstract.
How to cite.
How to present scientific works.
Draft deadline, feedback between students due one week later.
Report deadline and evaluation.
Presentations.

Special Features: The results from this course can be used as starting point for a possible Master thesis afterwards, if this is desired by the participant.
Teilnehmerzahl auf 15 begrenzt.

Robotics I

Credits: 5

Offered in the following semesters: WS 2025/26

Lecturer: Seel (thomas.seel@imes.uni-hannover.de)

Learning Objectives: Die Studierenden erwerben in diesem Modul grundlegende Kenntnisse von Entwurfs- und Berechnungsverfahren für die Kinematik und Dynamik von Industrierobotern sowie redundanten Robotersystemen. Die Studierenden werden mit Verfahren der Steuerung und Regelung von Robotern bekannt gemacht. Der Schwerpunkt liegt dabei auf der Erarbeitung klassischer Verfahren und Methoden im Bereich der Robotik.

Syllabus: - Direkte und inverse Kinematik

- Koordinaten- und homogene Transformationen

- Denavit-Hartenberg-Notation

- Jacobi-Matrizen

- Kinematisch redundante Roboter

- Bahnplanung

- Dynamik

- Newton-Euler-Verfahren und Lagrange'sche Gleichungen

- Einzelachs- und Kaskadenregelung, Momentenvorsteuerung

- Fortgeschrittene Regelverfahren

- Sensoren

Special Features: Diese Vorlesung wird mit wechselndem Dozenten, jedoch identischem Inhalt in jedem Semester angeboten. Im Sommersemester wird die Vorlesung von Prof. Müller des IRT und im Wintersemester von Prof. Seel des IMES gelesen.

SLAM (Simultaneous Localization and Mapping) and Path Planning

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Brenner (claus.brenner@ikg.uni-hannover.de)

Learning Objectives: This lecture imparts the basic principles about localization, mapping and simultaneous localization and mapping (SLAM), as well as basic methods for path planning.
After successful completion of the lecture, students are able to explain the principles and algorithms in SLAM and path planning. They can implement selected methods and are thus able to understand modules of available robotics packages.

Syllabus: Robot motion model. Laserscanning and landmark detection. Positioning using estimation of a similarity transform. Iterative closest point method. Bayes filter. Parametric filters and the Kalman filter. Variances and error ellipses. Extended (EKF) and multidimensional Kalman filter. Histogram- and particle filter. EKF SLAM. Rao-Blackwellized particle filter SLAM (FastSLAM). Path planning: Dijkstra and A* algorithms, potential functions, path planning in the kinematic state space. In the exercises, most of the algorithms will be programmed in the programming language Python.

Special Features: Online Course, programming exercises are part of the exam.

Scientific Data Management and Knowledge Graphs

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: N.N.

Learning Objectives: The students have learned in this course the main challenges of scientific data representation and integration. Knowledge graphs are expressive data structures to model, merge, and encode knowledge spread across heterogeneous data sources. The Students can analyze Graph models and ontologies in terms of expressive power and efficient management and storage. Moreover, they have learned existing ontologies for describing data sources and data integration. Finally, they know principles for making knowledge graphs available, and data management methods for enhancing transparency and traceability.

Syllabus: This course will cover the following topics: 1) Fundamental concepts of data integration systems and applications in scientific data management. 2) Resource Description Framework (RDF), Property Graphs, and RDF*. 3) Mapping languages to define the process of knowledge graph creation. 4) Ontological formalisms and controlled vocabularies to document integrity constraints (e.g., SHACL), provenance (e.g., PROV-O), and content (e.g., DCAT). 5) Methods for entity linking and data integration. 6)Approaches for constraint validation and quality assessment. 7) Federated query processing over knowledge graphs. 8) Knowledge graph completion and methods for link prediction. 9) Methods for creating findable, accessible, interoperable, and reusable data (e.g., FAIR principles). 10) Best practices for scientific data collection, and for maximizing data availability and transparent use (e.g., TRUST principles).

Seminar on Scientific Data Management

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: Vidal (vidal@L3s.de)

Learning Objectives: Students will learn and understand new research results and technologies in scientific data management and knowledge graphs. Best practices and methodologies to read and evaluate academic papers will be discussed. Results and shortcomings of scientific work and existing technologies reported in the state of the art will be analyzed. The students will lead the analysis of the problems and solutions proposed in scientific publications. The results of the discussions will be summarized in a written report and analyzed in an oral presentation.

Syllabus: The seminar will cover the following aspects: i) Methodologies for analyzing scientific literature. ii) Use of the scientific method in the empirical evaluation of data management and knowledge graphs. iii) Comparisons of state-of-the-art approaches. iv) Preparation of short and long presentations. v) Summarizing lessons learned in written reports.

Seminar: Artificial Intelligence

Credits: 3

Offered in the following semesters: SS 2025, WS 2025/26

Lecturer: Nejdl (nejdl@kbs.uni-hannover.de)

Learning Objectives: Die Studierenden können eigenständig ein Forschungsthema im Bereich Artificial Intelligence erarbeiten und es diskutieren.

Syllabus: Ausgewählte Literatur passend zum jeweiligen Thema. Das Seminar richtet sich an fortgeschrittene und wissenschaftlich interessierte Studenten der Informatik und angrenzender Fachgebiete. Es führt in aktuellen Themen von Artificial Intelligence sowie in das wissenschaftliche Arbeiten auf diesem Gebiet auf einem Niveau ein, wie es für fortgeschrittene Bachelor-Arbeiten oder Master-Diplom-Arbeiten sinvoll ist. Grundlage der (studentischen) Vorträge und Ausarbeitungen und daran anschließender Diskussionen sind aktuelle Artikel und Vorträge u.a. aus einschlägigen wissenschaftlichen Konferenzen und Zeitschriften.

Artificial Intelligence in Education

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: Kismihók (gabor.kismihok@tib.eu)

Learning Objectives: Die Studierenden verstehen wichtige Konzepte, Möglichkeiten und Herausforderungen der modernen, durch künstliche Intelligenz unterstützten Bildung, mit Schwerpunkt auf Personalisierung, offenen Bildungsressourcen (OER) und offener Software. Sie haben den Prozess der Nutzung von maschinellem Lernen, Text Mining und anderen KI-bezogenen Softwaretechnologien zur Lösung eines Bildungsproblems, einschließlich 1. Laden eines Datensatzes, 2. Datenbereinigung, 3. explorative Analyse der Daten, 4. Erstellung eines Modells und 5. Evaluierung der Ergebnisse, erlernt. Die Studierende haben Kooperationsfähigkeiten mit Menschen aus verschiedenen Disziplinen entwickelt, um gemeinsame Ziele bei der Entwicklung von Lernsoftware und didaktischen Konzepten zu erreichen. Sie sind fähig, in einem begrenzten Zeitrahmen ein KI-Konzept für Bildungssoftware zu erarbeiten und zu evaluieren. Sie haben gelernt, wie man ein KI-Projekt im Bildungsbereich aufbaut und Aufgaben und Verantwortlichkeiten für eine schnelle Entwicklung teilt. Und sie haben ihre Präsentationsfähigkeiten verbessert.

Syllabus: Das Seminar ist wie ein Hackathon aufgebaut, wobei der Schwerpunkt auf Diskussionen und interdisziplinärer Zusammenarbeit liegt. Während des Seminars werden Teams gebildet, die an einem KI-Software-Prototyp arbeiten. Die Teams müssen ihre anfänglichen Ziele in Bezug auf ihr Softwarekonzept besprechen, eine Zwischendiskussion im Vollkreis über ihre Fortschritte führen und schließlich ihre Ergebnisse präsentieren. Das Feedback zu den Fortschritten wird von den Dozenten nach Bedarf gegeben.
Während des Seminars werden die folgenden Themen mit den Seminarleitern im Detail besprochen:
1. Einführung in den Kurs (technologiegestütztes Lernen) (1 Sitzung). a. Was ist technologiegestütztes Lernen (und/oder Learning Analytics)? b. Was ist das Ziel des Kurses? c. Was werden wir im Kurs tun?
2. Definition der Probleme, die wir lösen werden (ein Problem pro Student/Gruppe). a. Qualitätssicherung der Inhalte (Reise-/Kurs-/Themenebene). b. Stimmungsanalyse von Bewertungen im Bildungsbereich. c. Wie wählen wir ein Problem aus, das wir lösen wollen?
3. Erforschung der Literatur/Werkzeuge. a. Suche nach einer sinnvollen Wissenslücke. b. Eindeutige Definition des Zielproblems. c. Datenerhebung. d. Bewertungsstrategie.

4. Methoden des maschinellen Lernens, die wir verwenden werden. a. Text Mining. b. Regressions-Modelle. c. Klassifizierungsmodelle
5. Python-Programmierkenntnisse, die wir für die Implementierung benötigen. a. Grundlegende Python-Programmierkenntnisse. b. Data Science-bezogene Libraries.
6. Implementierung und Bewertung
7. Vorschlagen/Präsentieren der Lösung

Seminar: Cryptographic Foundations of Secure Messaging

Credits: 3

Offered in the following semesters: WS 2025/26

Lecturer: Riepel (fahl@sec.uni-hannover.de)

Learning Objectives: Students will learn how to work with scientific literature and how to prepare and give a scientific talk. Students gain an in-depth understanding of security properties and functional requirements of end-to-end encrypted secure messaging applications. They will learn how these properties are defined formally and how cryptography helps to achieve them. By the end of the seminar, students can assess the security of real-world messaging protocols such as the Signal protocol.

Syllabus: Students will pick from a list of research papers on the topic. Papers will cover fundamental cryptographic definitions such as confidentiality, authenticity, forward secrecy, post■compromise security and deniability. To ensure that students have sufficient background to read cryptography papers, there will be an introduction session at the beginning of the semester which covers basic concepts of provable security as well as about reading and presenting scientific papers. At the end of the semester, each student is expected to present the results and approaches of one paper. Furthermore, a written report needs to be finished prior to presenting. During the semester, students have the opportunity to ask questions in dedicated Q&A; sessions.

Hybrid Artificial Intelligence

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: Kudenko (kudenko@l3s.de)

Learning Objectives: 1. Grundlegendes Verständnis von Hybrider KI und Neuro-Symbolischen Ansätzen.
2. Überblick über den State-of-the-art in Hybrider KI.

Syllabus: In the first decades of AI research, the focus was on symbolic, knowledge-based reasoning, e.g. logic-based representations and inferences, rule-based systems. The advantage of such approaches are that the AI behaviour is for the most part transparent and provable. However, the computational complexity of these approaches did prevent AI from being applied to many real-world applications. With the success of deep neural networks this has changed, and AI systems are increasingly permeating modern technology. However, this comes at the cost of transparency and safety guarantees. As a result, a new field of AI research is emerging that attempts to combine the classic symbolic approaches with the modern sub-symbolic (i.e. neural) technologies. In this seminar students will explore this new research area and gain a fundamental understanding of the directions taken. The following topics will be covered:

1. Neuro-Symbolic Computing
2. Approaches based on "Thinking Fast and Slow"
3. Hybrid Reinforcement Learning

Conference Seminar Usable Security and Privacy

Credits: 3

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Dürmuth (duermuth@sec.uni-hannover.de)

Learning Objectives: - The students are able to write a short paper, applying the basics of scientific writing. - The students are able to evaluate and provide feedback on papers written by other classmates. - The students are able to incorporate feedback received by others. - The students are able to present the content of their own work in front of the other students.

Syllabus: - Procedure and standards at "Scientific Conferences". - Short introduction/recap to scientific writing. - Understanding a topic in the field of usable security and privacy. - Preparing a short paper on the topic. - Performing a “review cycle” on the paper similar to a real conference. - Presenting the paper at a miniature conference.

Seminar: Natural Language Generation

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: Natural language generation (NLG) deals with the computational synthesis of natural language texts. The goal is either to create new texts based on information from knowledge bases or to rewrite a given text into another text with specified properties. In the last years, NLG has made tremendous advances due to the development of powerful neural language models. Common tasks in NLG include automatic response generation, text style transfer, summarization, and debiasing. The aim of this seminar is to learn about state-of-the-art research in NLG as well as to discuss benefits, limitations, and ethical concerns of technologies that generated text.

Syllabus: Based on a few introductory talks, each participant will choose a sophisticated topic from recent related research. For this topic, knowledge from different literature has to be acquired and presented in a scientific talk. The talks are given in weekly sessions during the lecture time. In addition, the topic has to be summarized and discussed in detail in a paper-like article to be submitted in the middle of the lecture-free time.

Special Features: The maximum number of participants is 16. The seminar grade depends on the talk (~50%), the article (~40%), and participation (~10%). All three aspects need to be passed individually.

Seminar: Quantum Information

Credits: 3

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Hirche (hirche@tnt.uni-hannover.de)

Learning Objectives: The course is aimed at students in the Master's programs in Computer Science and Technical Computer Science. Topics include current research areas in quantum information theory, quantum computing, and information processing. Assigned recent scientific texts on these topics are to be independently worked through, summarized in a written paper, supplemented with individual contributions, and finally presented in a talk.

Syllabus: After a brief introduction to the formalism of quantum information, the course will focus on recent publications around the topic of the seminar.

Seminar: Solving Complex Tasks using Large Language Models

Credits: 3

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: D’Souza (jennifer.dsouza@tib.eu)

Learning Objectives: Prompt engineering stands as the cornerstone technique essential for harnessing the full potential of Large Language Models (LLMs). It enables the precise tailoring of inputs to LLMs, enhancing the management of complex tasks, improving accuracy in generating desired outputs, and boosting the ability to evaluate and interpret diverse data sets. Students learned prompt engineering techniques to enable LLMs to handle complex tasks, as well as using LLMs to evaluate complex results. The seminar features literature topics. The goal of the literature topics is two-fold: 1) 1) students can read, understand and research scientific literature; and 2) they can critically summarize the state of the art regarding the application and evaluation of LLMs. In other words, students gain a deep insight into the latest literature on innovative applications and assessments of LLMs. Additionally, students have the option to conduct small-scale experiments to assess the effectiveness of advanced prompt engineering techniques through hands-on practice. However, completion of experiments is not mandatory for successfully completing the seminar.

Syllabus: Based on a few introductory talks, participants will receive a list of sophisticated topics from recent research, from which they can select one for further study as their literature topic for the seminar. Examples can include: “Prompt Search/Breeding”, “Limitations of LLMs”, “LLM Self-Evaluation during Fine-tuning”, “ LLMs as Evaluation Metrics”, “Evaluation of Code Writing Ability of LLMs”. For the chosen topic, knowledge from different literature has to be acquired and presented in a scientific talk. Thus for each topic, 2 or 3 preselected papers are offered as reading material. The talks are given in weekly sessions during the lecture time. In addition, the topic has to be summarized and discussed in detail in a paper-like article to be submitted in the middle of the lecture-free time.

Special Features: The seminar grade depends on the talk (~50%), the article (~40%), and participation (~10%). All three aspects need to be passed individually.

Seminar: Dependable and Scalable Systems

Credits: 3

Offered in the following semesters: SS 2025

Lecturer: Rellermeyer (rellermeyer@vss.uni-hannover.de)

Learning Objectives: After this course, students will be able to: 1. know basic presentation techniques. 2. read and understand scientific articles on contemporary topics of scalable and dependable systems. 3. know how to describe and interprete the core content of a scientific article using best practices in scientific writing and citation guidelines. 4. analyze and critique scientific work using domain-specific criteria. 5. perform a literature search and identify relevant related work. 6. present and discuss the core contributions of scientific work in a presentation in front of an audience. 7. reflect on strengths and weaknesses of the own presentation skills. 8. being able to make constructive criticism. 9. participate actively in a scientific discussion.

Syllabus: Will be published shortly before the start of the semester.

Seminar: Distributed Real-time Systems

Credits: 3

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Rizk (amr.rizk@ikt.uni-hannover.de)

Learning Objectives: In this seminar the students will learn to extract a scientific problem statement from scientific papers. They will learn to analyze, contrast and critique multiple approaches to that problem in the area of distributed real-time systems. The students will present their findings in the course of the seminar in addition to handing in a seminar paper.

Syllabus: The topics and the literature will be published at the preliminary meeting at the beginning of the semester. The topics of the seminar are in the current research areas of: (1) mathematical analysis of communication systems, (2) programmable communication systems, (3) network coding, (4) Event-based vision sensing, (5) point cloud compression

Mobile System Security

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Bugiel (bugiel@cispa.de)

Learning Objectives: This advanced lecture deals with different fundamental aspects of mobile operating systems, mobile application frameworks, and application security, focusing very strongly on the popular, open-source Android OS and its ecosystem. In general, the awareness and understanding of the students for security and privacy problems in this area are increased. The students learn to tackle current security and privacy issues on smartphones from the perspectives of different stakeholders in the smartphone ecosystem: end-users, app developers, market operators, and device vendors.
The lectures are accompanied by exercises to reinforce the theoretical concepts and to provide an environment for hands-on experience for mobile security on the Android platform. Additionally, a short course project should give hands-on experience in extending Android's security architecture with a simple custom mechanism for access control enforcement.

The lecture will very likely take place in a “flipped classroom” format.

Syllabus: - Basics of Android app development
- Essential security concepts (e.g., secure architecture principles or mandatory access control) and deep dive into Android's security architecture
- App compartmentalization and defensive programming (e.g., integration of third-party libraries)
- UI deception attacks and sensory side-channels
- Network Security (TLS, WebViews, DeepLinks)
- Basics of hardware-based mobile platform security
- Comparison to Android Automotive, Wear OS, Google Fuchsia, and iOS

Special Features: Kursinhalte werden voraussichtlich über das CMS vom CISPA Helmholtz Zentrum für Informationssicherheit bereitgestellt: https://cms.cispa.saarland/

Side-Channel Attacks and Defenses

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Schwarz (michael.schwarz@cispa.de)

Learning Objectives: Die Studierenden kennen verschieden Arten von Seitenkanalangriffe in Software und Hardware und deren Gegenmaßnahmen. Sie haben vertiefte theoretische Kenntnisse von Seitenkanälen und habe sie praktisch in mehreren Programmierprojekten erprobt. Sie verstehen die Angriffe und die Gegenmaßnahmen sehr gut und können diese implementieren und evaluieren.

Syllabus: Diese Vorlesung behandelt Seitenkanalangriffe in Software und Hardware und deren Gegenmaßnahmen. Es gibt Seitenkanäle in der CPU, die man in Software ausnutzen kann, um auf geheime Daten zuzugreifen. Die Vorlesung gibt einen Überblick über die verschiedenen Arten von Seitenkanälen, Angriffstechniken, und Gegenmaßnahmen. Behandelt werden klassische Seitenkanäle wie Timing-, Stromverbrauch, und Cache Angriffe, deterministische Seitenkanäle wie Page-Table-Angriffe, und weitere Sicherheitsprobleme, bei denen Seitenkanäle eine integrale Rolle spielen, wie Transiente Ausführungsangriffe (Meltdown und Spectre), software-basierte Fehlerangriffe, und andere CPU Sicherheitslücken.

Social Computing

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Elejalde Sierra (elejalde@l3s.de)

Learning Objectives: Die Studierenden haben vor dem Hintergrund des Aufstiegs sozialer Online-Plattformen (Facebook, Wikipedia, Twitter, Instagram, Blogs, Open-Source-Entwicklungsprojekte, Crowdsourcing-Plattformen u.a.) gelernt, dass die Webtechnologie nicht nur zur Verbreitung von Informationen dient, sondern auch dazu, Menschen miteinander zu verbinden.

Sie kennen die Ansätze des Social Computing, welches sowohl die sozialen Prozesse als auch die Technologie, die sie ermöglicht und verbessert, untersucht. Dabei fließen Erfahrungen aus verschiedenen Bereichen ein, darunter Kognitionswissenschaft, Softwaretechnik, künstliche Intelligenz, Soziologie, Anthropologie, Psychologie und Organisationsverhalten.

Die Teilnehmer haben eine Reihe von organisatorischen, technischen und geschäftlichen Hürden, die mit Social Computing verbunden sind, erforscht. Außerdem haben sie Fähigkeiten zur Analyse, zum Design und zum Aufbau von Online-Communities unter Verwendung einschlägiger Tools erworben.

Die Studierenden haben Fertigkeiten in praktischer mündlicher, schriftlicher und visueller wissenschaftlicher Kommunikation vertieft sowie Fähigkeiten zur Reflexion über die gesellschaftlichen Auswirkungen der Datenwissenschaft erlangt.

Syllabus: Der Schwerpunkt dieses Kurses liegt auf der Untersuchung der Verflechtung und Komplexität von Daten, Algorithmen, Individuen, sozialem Kontext und der Umwelt. Wir erforschen die bewusste Gestaltung und Entwicklung von werteorientierter, sozialer und nachhaltiger Technologie.
Die Kursarbeit umfasst Vorlesungen, Diskussionen in der Klasse, Hausaufgaben, Präsentationen und ein Forschungs- oder Entwicklungsprojekt in der Gruppe.

Social Responsibility in Machine Learning

Credits: 5

Offered in the following semesters: SS 2025, SS 2026

Lecturer: Lindauer (lindauer@tnt.uni-hannover.de)

Learning Objectives: Students learn to engage with current research from the fields of ethical and reliable machine learning, and theory of science. Critical discussion of this research both encourages and trains their skills in scientific discourse. A poster presentation will furthermore improve the students' scientific presentation skills during the semester in preparation for the final project.

Syllabus: The covered content includes, but is not limited to: Data & Objectivity, Data Collection, Case Studies, Fairness Optimization, Error-Contributing factors, Limitations of Technical Solutions, Models in Deployment, Environmental Impact of ML, Application Ethics, Who's responsible?

Special Features: Teilnahmebeschränkung: 40
(durch Raumgröße beschränkt)

Spatial Data Science

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Sester, Feuerhake (monika.sester@ikg.uni-hannover.de; udo.feuerhake@ikg.uni-hannover.de)

Learning Objectives: The course will introduce advanced spatial data analysis and processing methods, namely approaches
from AI, Data Mining and computational geometry. Students will understand and program selected
algorithms and will be able to apply them to different relevant applications fields. The course will
consist of lectures and exercises, as well as small group works.

Syllabus: Students will get acquainted with methods to analyse and process spatial data using spatial data
science approaches and computational geometry methods. These methods are needed to process
spatial data such as vector map data, trajectories, or VGI data. Methods for automatic data
generalization, classification clustering and prediction will be presented. Application fields lie in the
domains of mobility, autonomous driving and geo risks.

Special Features: Lectures and exercises; Jupyter Notebooks, home assignment (small group work)

Statistical Natural Language Processing

Credits: 5

Offered in the following semesters: WS 2024/25, WS 2025/26

Lecturer: Wachsmuth (h.wachsmuth@ai.uni-hannover.de)

Learning Objectives: In this course, students learn the most important skills required for typical natural language processing (NLP) tasks using statistical methods. Starting from basics of NLP and machine learning, students learn the main learning-based NLP techniques, from clustering and classification to sequence labeling, neural networks, transformers, and large language models. The application of these techniques is exemplified for various NLP tasks, such as topic modeling, sentiment analysis, and coreference resolution. The students learn to develop and evaluate respective NLP methods, both theoretically and in practical assignments.

Syllabus: Lecture parts: Overview of Statistical NLP, Basics of NLP, Basics of SNLP, NLP using Clustering, NLP using Classification, NLP using Sequence Labeling, NLP using Neural Network, NLP using Transformers and LLMs, Practical Issues

Special Features: Notice that this course does not include any programming tasks. Ideally, the lab "Human Language Technology" is taken in parallel with this course, which complements this course with programming tasks.

Text Mining

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Sikdar (sandipan.sikdar@l3s.de)

Learning Objectives: Die Studierenden haben gute Kenntnisse über Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks und Transformer Models.

Syllabus: Neural Networks, Convolutional Neural Networks, Recurrent Neural Networks, Transformer Models.

Circuit Complexity

Credits: 7

Offered in the following semesters: SS 2026

Lecturer: Vollmer (vollmer@thi.uni-hannover.de)

Learning Objectives: The module provides in-depth knowledge of the theoretical circuit model. Upon successful completion of the course, students will be able to analyse algorithmic problems with regard to their circuit complexity. They will evaluate the consequences of upper and lower bounds in the circuit model. They will develop Boolean circuits for new algorithmic problems. They will study current research literature, summarise it in writing and present it orally.

Syllabus: In this lecture, we will examine the computational model of Boolean circuits. Boolean circuits are directed acyclic graphs in whose nodes (gates) Boolean functions (such as AND, OR, NOT) are evaluated. We will examine various basic functions (addition, multiplication, sorting, etc.) and construct circuits that implement these with as few gates as possible or with the shortest possible path lengths between input and output.Outline:Boolean circuits and their complexity measures, circuits for basic functions (addition, multiplication, threshold), reductions, reductions between basic functions (iterated addition, multiplication, sorting, iterated multiplication), TC0 vs. NC1, lower bounds for general circuits (parity, threshold), probabilistic circuits, circuits with MOD gates, lower bounds for AC0(p), circuits and polynomials, Smolensky's theorem.

Parameterized Complexity Theory

Credits: 7

Offered in the following semesters: WS 2026/27

Lecturer: Vollmer (vollmer@thi.uni-hannover.de)

Learning Objectives:
The module provides in-depth knowledge of concepts, techniques and phenomena of parameterised complexity theory. Upon successful completion of the course, students will be able to analyse algorithmic problems with regard to their parameterised complexity. They will evaluate the dependence of complexity on structural properties of the input instance. They will develop classifications of the difficulty of computational problems depending on input parameters. They will study current research literature, summarise it in writing and present it orally.

Syllabus: The class FPT. Reductions. The W hierarchy. Logic and complexity. Paradigms of algorithm design.