Master of Science in Computer Engineering

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

Lecture Overview

Number of modules offered in English language: 51

Lecture Name	Last Semester	Regularly	Credits
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
Creation and Application of Knowledge Graphs	WS 2025/26	Winter	5
Data- and Learning-Based Control	WS 2025/26	Winter	5
Deep Learning Foundations	WS 2025/26	Winter	5
Digital Image Processing	SS 2025	Summer	5
Efficient Algorithms	WS 2025/26	Winter	7
Formal Languages	SS 2027	Summer	7
Foundations of Information Retrieval	WS 2025/26	Winter	5
Data Science Foundations	WS 2025/26	Winter	5
Hardware-accelerated Communication Systems	WS 2025/26	Winter	5
Interpretable Machine Learning	WS 2025/26	Winter	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
Advanced Logics	SS 2026	Summer	7
Methods of User Authentication	WS 2025/26	Winter	3
Mobile Interaction	SS 2025	Summer	5
Model Predictive Control	SS 2025	Summer	5
Multi-Agent Interactions and Games	WS 2025/26	Winter	5
Nonlinear Control	WS 2025/26	Winter	5

ASIPLab: Design of Application-Specific Instruction-Set Processors	SS 2025	Summer	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
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
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: 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 Responsibility in Machine Learning	SS 2026	Summer	5
Text Mining	SS 2025	Summer	5
Circuit Complexity	SS 2026	Summer	7
Parameterized Complexity Theory	WS 2026/27	Winter	7

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.

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.

Data- and Learning-Based Control

Credits: 5

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

Lecturer: Lopez Mejia (lopez@irt.uni-hannover.de)

Learning Objectives: The students are familiar with state-of-the art methods for data- and learning-based control as well as the underlying theory. They are able to implement the presented methods and can read and discuss publications on past and ongoing research in this field.

Syllabus: In this course, different data- and learning-based control design techniques are considered. Data-based approaches compute controllers directly from the available input and output data, without the intermediate step of identifying a model of the system. In particular, we will discuss virtual reference feedback tuning, control design based on Willems' fundamental lemma, and the data informativity framework. In learning-based control, some machine learning technique is employed to learn a model of the system (or unknown parts thereof) or directly a suitable controller. Within this course, we will in particular consider approaches from reinforcement learning, using Gaussian Processes, and neural networks.

The methods presented in this lecture are helpful for a safe, resource-saving and sustainable application of technical processes and procedures.

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!

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.

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.

Data Science Foundations

Credits: 5

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

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

Learning Objectives: In the Era of Big Data, one of the emerging requirements for any scientist is the ability to effectively and critically work with data, i.e., collect and extract data, create surveys, transform the data, apply mathematical models on the data, and visualize the important aspects. In fact, the Society of Computer Science (Gesellschaft der Informatik) has coined the term “data literacy” to describe various competencies in this regard. In the same spirit, the goal of this course is to teach non-computer scientists the foundational concepts of data science. Students will learn to analyze data for the purpose of understanding and describing real-world phenomena.
The students will obtain skills in data-centric programming and statistical inference. Furthermore, the students will gain hands-on experience on daily challenges of a data scientist with best-practice approaches for data collection and preparation.

The course consists of a inverted-classroom lecture and lab work. During the lecture the important concepts are introduced. In the lab sessions, students will be guided in practical programming exercises. In addition, the students receive bi-weekly assignments that follow-up on the lab exercises.

Syllabus: - Data Sampling and Probability
- Data Preparation
- Visualizations
- Introduction to Modeling
- Learning Paradigms
- Classification
- Deep Learning
- Feature Engineering
- Bias and Variance
- Evaluation
- Automated Machine Learning
- Conclusion

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

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.

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.

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

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.

Model Predictive Control

Credits: 5

Offered in the following semesters: SS 2025

Lecturer: Müller (mueller@irt.uni-hannover.de)

Learning Objectives: The students analyze and synthesize various types of model predictive controllers for different system classes and implement them in Matlab. They are able to derive systems-theoretic guarantees of MPC controllers, including closed-loop stability and robustness, and can assess the different properties, advantages, and disadvantages of different MPC schemes. The students have insight into current research topics in the field of model predictive control, which enables them to do their own first research projects in this area.

Syllabus: This lecture deals with Model Predictive Control (MPC), a modern optimization-based control technique which has been actively researched and widely applied in industry within the last years. After an introduction to the basic ideas and stability concepts of MPC, more recent and current advances in research, like tube-based MPC considering robustness issues, economic MPC, distributed MPC, and stochastic MPC are discussed.

The methods presented in this lecture are helpful for a safe, resource-saving and sustainable application of technical processes and procedures.

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 .

Nonlinear Control

Credits: 5

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

Lecturer: N.N.

Learning Objectives: This course covers modern analysis and controller design methods for nonlinear systems. After this course, students should be able to identify and analyze nonlinear control problems, select suitable control approaches, carry out a controller design and implementation.

Syllabus: - Lyapunov stability

- Input-to-state stability

- Control Lyapunov functions

- Backstepping

- Sliding-mode control

- Input-Output linearization

- Passivity and Dissipativity

- Passivity-based controller design

The methods presented in this lecture are helpful for a safe, resource-saving and sustainable application of technical processes and procedures.

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: 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.

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.

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: 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 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)

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.