Tracks (up to and incl. 2022/23)

Track “T0 – General”

Key Words

A collection of teaching units from a variety of subject areas, which supplement the teaching units, offered in the other 6 tracks.

Description

Complementary offer.

Track “T1 – Distributed Systems”

Key Words

Distributed systems, peer-to-peer networks, grid and cloud computing, mobile communications, concurrency, foundations and algorithms, verification and model checking, bio-inspired and parallel architectures, network security, pervasive and context-aware computing

Description

Most computer systems are inherently distributed, ranging from high performance computing systems to small devices, and are used pervasively by our society. The emblematic example of a distributed system is the Internet with its associated technologies like the Web, peer-to-peer networks, computing grids and clouds, and (wireless) communication networks. This trend toward distributed architectures is expected to continue, and even intensify, in the foreseeable future. Computing devices and applications increasingly interact with the users and with each other, either individually, collectively or collaboratively. It is therefore essential for a computer scientist to master the concepts, methods, and tools necessary for the development and management of distributed systems as well as wired/wireless communication systems.

This track deals with the theoretical foundations and the practical aspects of distributed systems engineering, both at the network / infrastructure and application level. Core courses cover the basics of distributed systems by exploring their underlying concepts, e.g., coordination or concurrency, foundations and algorithms, verification and model checking, or communication systems and protocols. Further courses address more specific aspects in relation to the domains of expertise of the different research groups at the universities hosting the Master. Examples include bio-inspired and parallel architectures, network security, advanced database systems and large-scale distributed systems, pervasive and context-aware computing, mobile / wireless communications, sensor networks, web engineering, and peer-to-peer networks.

Involved research groups:

- Communication and Distributed Systems (CDS)
- Complex Systems
- Cryptology and Data Security (CRYPTO)
- eXascale Infolab (XI)
- Foundations of Dependability and Security (FDS)
- Software Engineering (SoftEng)

Track “T2 – Advanced Software Engineering”

Key Words

Advanced methods for the analysis, development and testing of modern and reliable software systems in heterogeneous, service-oriented and closely connected system topologies

Description

Complex software systems are difficult to develop. Complexity arises from the need to integrate heterogeneous data models, programming languages and standards, the challenge of providing dependable services on open, networked systems, and the reality of continuously changing business requirements. Such systems are difficult to understand, to develop and to maintain. Software Engineering comprises state-of-the-art techniques in developing quality software products within time and budget constraints.

The track Advanced Software Engineering offers a study program that explores new and emerging techniques for managing the complexity of developing modern, dependable and flexible software systems. Certain courses examine trends in software engineering, such as agile methodologies and current development environments. Other courses examine the role of software engineering in modern application domains, such as web engineering, service oriented architecture (SOA), RESTful Web Services and mashups frameworks. Programming and development techniques are examined in courses dedicated to topics such as concurrent programming, compiler construction, and programming languages. Techniques to support software evolution are also studied, in particular the analysis of both static source code and running software systems to build up software models that can be studied, queried, and visualized to reveal hidden design knowledge and to expose potential problems.

Involved research groups:

- Complex Systems
- Digitalization and Information Systems (DIGITS)
- Software Engineering (SoftEng)
- Software Engineering Group (SEG)

Track “T3 – Advanced Information Processing”

Key Words

Signal processing for pattern recognition, document analysis, computational linguistics, (re)acquisition of information and computer graphics, as well as exposure to artificial intelligence

Description

The Information Age is characterized by technology to acquire and store vast amounts of data that can be shared and accessed by anyone from anywhere. This data may consist of text, images, video, sound, as well as handwriting, structured documents, or any organized database, etc. In short, the data may include any information that can be represented digitally. One of the main challenges in computer science today is to develop methods to process and analyse this data, and eventually to make it useful for a wide range of applications. Therefore, proficiency in fundamental methods for information processing is a core skill of computer scientists.

This track covers the foundations as well as advanced methods of information processing in a wide range of research and application areas. It includes courses on fundamental topics such as pattern recognition, machine learning, signal processing, and database systems. In addition, the track offers a wealth of courses that are aligned with the research interests of the groups involved. This includes image and document processing, natural language processing, human-computer interfaces, information retrieval and the internet, computer vision, and computer graphics.

Involved research groups:

- Computational Linguistics
- Computer Graphics Group (CGG)
- Computer Vision Group (CVG)
- Document, Image and Video Analysis (DIVA)
- Human-Computer Interaction
- Pattern Recognition Group (PRG)

Track “T4 – Logic”

Key Words

Computability and complexity, proof theory, lambda calculus, logic programming and proof search, classical and non-classical logics, universal algebra, automata, verification, knowledge representation, data privacy, data mining, ontologies, formal methods

Description

Logic can be called the “calculus” of computer science just like calculus is a basic language of natural sciences. But logic predates computer science and can rightfully be considered responsible for its very creation. Logicians laid out the basic properties of various forms of computations and of “thinking machines” at least half a century before the first computer was created. To this day, logic provides a theoretical framework for computer science and plays a prominent role in many of its applications. Studying logic, you learn about the general laws of reasoning and computing, and reasoning and computing are everywhere.

This track provides a thorough introduction into logic (building upon what you learnt in the bachelor program) and leads you to the forefront of research in several active areas, always from a computer science perspective. We will study issues of complexity and proof theory as well as logics for reasoning about knowledge and time, as they are being used in connection with verification problems in distributed environments. There will be courses on algebraic properties of logical systems and fuzzy logics. In addition, on the more applied side, we consider automata, questions of data privacy and knowledge management in structures like the semantic web.

Involved research groups:

- Foundations of Dependability and Security (FDS)
- Logic and Theory Group (LTG)

Track “T5 – Information Systems and Decision Support”

Key Words

eBusiness, eGovernment, information management, databases management systems and data ware-housing, fuzzy classification, decision support, quantitative models and methods of operations research, food supply

Description

Information and Communication Technologies (ICT) are pervasive in business and society. Internet, data warehouses and sophisticated applications enable new ways of conducting business and running highly efficient processes. Several key competences are required for the successful creation and deployment of information management applications on electronic platforms, from modeling languages to analytical methods and in-depth knowledge of infrastructures underpinning higher-level services. Leveraging ICT hence requires not only sound knowledge of the technical foundations of Computer Science, but also of the building blocks and architecture of information systems, of methods used in “intelligent” applications, as well as of management methods, e.g. in the deployment of e-processes.

This track addresses information systems through a technical and structural approach, through decision support methods in applications, as well as through concepts and methodology for their implementation in various contexts. Courses include topics such as fundamentals of advanced database systems, introduction to next-generation information management infrastructures, mathematical modeling techniques, combinatorial optimization methods, simulation and metaheuristics, models in revenue management, fundamentals of process management and e-business, and design and implementation issues of e-government projects.

Involved research groups:

- Decision Support & Operations Research (DSOR)
- Digitalization and Information Systems (DIGITS)
- Soft and Cognitive Computing

Track “T6 – Data Science”

Key Words

Big data, data analysis, cloud computing, large-scale distributed systems, machine learning, pattern recognition, social media analytics

Description

Data is the new oil, as it powers an increasing number of key aspects of our society. Be it for online recommender systems, environmental monitoring, simulation and modeling, or smart-city infrastructures, data has become a key ingredient in deploying and optimizing large-scale services. While data production is booming – driven by online applications, mobile devices and the Internet of Things – legacy infrastructures like relational databases or numerical computing frameworks are reaching their limits and are being rapidly replaced by a new ecosystem of software and methods for storing, manipulating and analyzing steadily growing amounts of data often referred to as Big Data.

This track covers both theoretical foundations as well as practical aspects of dealing with large quantities of potentially heterogeneous and noisy data. Core courses belonging to this track cover systems and techniques to store, process, and make sense of Big Data. Several courses focus on conceptual and architectural issues related to the design and deployment of modern data management infrastructures, with an emphasis on recent systems developed to solve large-scale problems using clusters of commodity machines. Further courses address data analysis and knowledge discovery from a number of different perspectives, including pattern recognition, online recommendation, or machine-learning using both unsupervised and supervised models. A wide set of applications ranging from targeted advertising to social network analysis or financial stream modelling are covered throughout the courses.

Involved research groups:

- Complex Systems
- Computational Linguistics
- Computer Graphics Group (CGG)
- Computer Vision Group (CVG)
- Data Science
- Document, Image and Video Analysis (DIVA)
- eXascale Infolab (XI)
- Human-Computer Interaction
- Pattern Recognition Group (PRG)
- Soft and Cognitive Computing