

COMPUTER SCIENCE, doctoral study programme, third Bologna cycle

Compulsory and elective course descriptions

COMPULSORY COURSES

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – SYSTEM THEORY AND INFORMATION ANALYSIS**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- the role of system theory in information system research;
- the concept of information systems artefacts as the core of the information system discipline;
- examples of influential theories in information system research, and their ontological, epistemological, and methodological assumptions and implication;
- theories on information technology and organizational change, innovation and strategy;
- theories on global issues in information systems.

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – PROGRAMMING LANGUAGES AND TECHNIQUES**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Model Driven Development/Architecture
- Model Transformation and Code Generation
- Models at Runtime
- Software Repository Mining
- Data Analytics in Software Engineering
- Defect Prediction
- Microservices
- Natural language processing techniques
- Infrastructure as Code
- Computing Paradigms
- Cloud Standards
- Parallel systems
- Continuous Delivery and DevOps
- Software engineering and AI
- Adaptive Learning Systems
- Light/object(s) interaction techniques
- Texture and environment mapping
- Raytracing algorithms
- Multiresolution modeling
- Physically based modeling
- Deformation modeling
- Advanced real-time rendering

- Radiosity
- Computer vision and (multi-view) geometry
- Learning based methods in computer vision
- Motion analysis and activity recognition
- The use of the above in animations, simulations and 3D user interfaces

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – DATA STRUCTURES AND ALGORITHMS**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Partial and Full persistence
- Purely functional data structures (concatenable lists)
- Deamortization and Dynamization techniques
- Sorting and Priority queues
- List order maintenance
- Interpolation search
- Deterministic hashing
- Priority queues: Binomial, Fibonacci, Skew heaps
- Finger search trees
- RAM data structures
- Least common ancestor data structures
- Succinct data structures
- Implicit data structures
- van Emde Boas data structures
- Union-(split-)find data structures
- Taxonomy of parallelism: Flynn's classification
- Vector, SIMD, MIMD computers
- Programming of parallel computers
- Energy efficiency
- Customized architecture with specific algorithms
- Distributed computing
- Formal models and computational complexity of parallel computing
- Design in the analysis of parallel algorithms
- Linear programming
- Paaralel, String, Online, Approximation, Fixed-Parameter, External-Memory, Streaming Algorithms
- Computational Geometry

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – COMPUTER COMMUNICATIONS AND COMPUTING SYSTEMS**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- Foundations and design of sensor networks
- Performance evaluation
- Architectural developments
- Advances in allocation algorithms
- Service discovery and selection

- Scheduling optimization
- Energy related issues
- Communication with and between sensors
- Domain-specific aspects of sensor data
- Mediation solutions for data heterogeneity problems
- Failure recovery in shared systems
- Distributed transaction processing
- Information diffusion
- Security, Semantics, Protocols
- Environments for massively distributed data collection and processing
- Sensor networks and Machine Learning
- Fusion-based sensor networks
- Advanced machine learning techniques
- Deep learning
- Active learning
- Applications of artificial intelligence
- Agent technologies
- Large scale data mining
- Temporal pattern mining
- Social media analytics
- Statistical data analysis
- Information visualisation techniques
- Opinion Mining and Sentiment Analysis
- Statistical modeling
- Recommender systems
- Viral marketing

Course name: **IN-DEPTH COURSE IN COMPUTER SCIENCE – THEORETICAL COMPUTER SCIENCE**

Number of ECTS credits: **9**

Content:

The course will cover a range of topics that might include (but are not restricted to) any of the following according to the needs and development of the subjects covered:

- random graphs
- permutation groups
- hypergraphs and Boolean functions
- advanced topics in coding theory
- advanced counting techniques
- random walks on graphs
- graph decompositions
- the probabilistic method in combinatorics
- discrete Fourier analysis and applications
- connection of the above with information theory and algorithms
- information theoretic vs. computational security
- fast hash based signatures
- elliptic curve cryptography and pairings
- lattice based cryptography
- malleable cryptography
- analysis of number theoretic assumptions
- primality testing and factorization
- blockchain and Cryptocurrencies
- zero-knowledge proofs and interactive protocols

- searchable encryption
- multi-party secure computation

Course name: **INDIVIDUAL RESEARCH WORK 1**
Number of ECTS credits: **30**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be than presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK 2**
Number of ECTS credits: **24**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be than presented orally to the audience.

Course name: **INDIVIDUAL RESEARCH WORK 3**
Number of ECTS credits: **54**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/report. Article/Report needs to be presented orally to the audience.

Course name: **SEMINAR 1**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Course name: **SEMINAR 2**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.
Passive participation at national or international conference is expected.

Course name: **SEMINAR 3**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Active participation at national or international conference is expected.

Course name: **SEMINAR 4**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Active participation at national or international conference is expected.

Course name: **SEMINAR 5**
Number of ECTS credits: **6**

Content:

Students prepare either a review or their own study for a selected research topic and write an article/research report. Article/research report needs to be presented orally to the audience.

Presentation of the thesis is expected.

ELECTIVE COURSES

Course name: **SCIENTIFIC SKILLS - DESIGN AND ANALYSIS OF PLANNED EXPERIMENTS**
Number of ECTS credits: **6**

Content:

The student will become familiar with the following topics in experimental design and analysis, with an emphasis on data capture, data preparation and statistical analysis:

- Identifying and expressing hypotheses
- Sampling, experimental units, replication
- Factors and levels
- Relationship between sample size, predictive power, and planned analysis
- Randomisation
- One-way layouts
- Matched pairs
- Fixed effects, random effects, mixed effects
- Factorial arrangement
- Blocking, latin squares, split plots, nesting
- Analysis and reporting in R
- Other topics in analytics

Course name: **SCIENTIFIC SKILLS - SCIENTIFIC WRITING AND PRESENTATION**
Number of ECTS credits: **6**

Content:

Students will review and practice key skills in scientific writing and presentation:

- Reporting scientific results
- Structuring scientific writing
- Oral presentations of scientific results
- Presenting science to non-scientific audiences
- Argument and persuasive writing
- Proposal writing
- Poster presentation

- Role of graphics and visualisation
- Resource management tools and citation