List of Master Modules that We Teach in English on Request

Institute of Computer Science, University of Würzburg

<table>
<thead>
<tr>
<th>abbr.</th>
<th>type²</th>
<th>module name</th>
<th>CP²</th>
<th>lecturer³</th>
<th>term⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-I=SEM₃</td>
<td>seminar</td>
<td>Seminar 1 - Current Topics in Computer Science</td>
<td>5</td>
<td>various</td>
<td>S+W</td>
</tr>
<tr>
<td>contents:</td>
<td>Independent review of a current topic in computer science based on literature and if applicable software with written and oral presentation.</td>
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<td>intended learning outcomes:</td>
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<tr>
<td>10-I=SEM₄</td>
<td>seminar</td>
<td>Seminar 2 - Current Topics in Computer Science</td>
<td>5</td>
<td>various</td>
<td>S+W</td>
</tr>
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<tr>
<td>10-I=PRAK</td>
<td>practical</td>
<td>Practical Course - Current Topics in Computer Science</td>
<td>10</td>
<td>various</td>
<td>S+W</td>
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<tr>
<td>contents:</td>
<td>Handling of a practical task.</td>
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<tr>
<td>intended learning outcomes:</td>
<td>The practical allows the participants to work on a problem of computer science in a team.</td>
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<tr>
<td>10-I=CSD</td>
<td>project</td>
<td>CanSat / FloatSat Design Workshop</td>
<td>9</td>
<td>Prof. Montenegro</td>
<td>W</td>
</tr>
<tr>
<td>contents:</td>
<td>CanSat (new name: FloatSat) is an interdisciplinary project designed - but not only - for SpaceMaster students. It is for students with different backgrounds, like for example computer science, electronics, mechanical engineering, aerospace technology, physics, mathematics. A satellite project is an interdisciplinary project, we need knowledge in this and many other fields. Therefore, CanSat is an ideal platform to combine all available skills in a single project. It covers design and development of space segment control software ground segment software: Telemetry and telecommanding wireless communication: space segment &lt;-&gt; ground segment electrical subsystem (energy, batteries) mechanical construction.</td>
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<td>intended learning outcomes:</td>
<td>The students shall build and integrate inside of the sphere the power unit, a control computer, a payload (camera) and attitude control devices: Gyros and reaction wheel of a pico satellite. The software of a CanSat &quot;satellite&quot; covers real time operating system (provided by us), commanding (immediate and time tagged commands), telemetry (real time and history data) attitude control, power control, payload control, image processing and radio links communication. The ground segment shall be able to generate and send telecommands and to get and display (in a graphical way) the telemetry.</td>
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¹ most lectures include (practical) exercises
² Credit Points in ECTS (European Credit Transfer System)
³ when no specific lecturer is given, general responsibility lies with the Dean of Studies (Prof. Nüchter)
⁴ S = summer term (mid-April to mid-July), W = winter term (mid-October to mid-February), S+W = summer and winter term, S/W = summer or winter term
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<tr>
<td>10-I=RO₁</td>
<td>lecture</td>
<td>Robotics</td>
<td>8</td>
<td>Prof. Schilling</td>
<td>W</td>
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<tr>
<td>10-I=RO₂</td>
<td>lecture</td>
<td>Robotics 2</td>
<td>8</td>
<td>Prof. Schilling</td>
<td>S</td>
</tr>
</tbody>
</table>
|       | contents: | Basics of dynamic systems, controllability and observability, controller design through pole assignment: feedback and feed-forward, state observer, feedback with state observer, time discrete systems, stochastic systems: basics of stochastic, random processes, stochastic dynamic systems, Kalmanfilter: derivation, initializing, application examples, problems of Kalmanfilters, extended Kalmanfilter  
|       | intended learning outcomes: | The students master all necessary basics for the understanding of Kalmanfilters and their use in applications of robotic. They possess knowledge of advanced controller and observer methods and realize the connections between the dual pairs controllability-observability and controller- and observer-design as well as the relationship between Kalmanfilter as a state estimator and an observer. |       |           |       |
| 10-I=SSD | lecture | Spacecraft Systems Design   | 8   | Prof. Schilling | W     |
|       | intended learning outcomes: | The students master system aspects of layouting of technical systems. Using the example of spacecraft, major subsystems and their integration in a working whole are being analyzed. |       |           |       |
| 10-I=SD | lecture | Space Dynamics               | 5   | Prof. Schilling | W     |
|       | contents: | Basics of astrodynamics, orientation control of satellites, sensors, actuators, control software, example realizations, spin stabilized satellites, 3-axis stabilized satellites.  
|       | intended learning outcomes: | The students master the basics of dynamic aspects of design of spacecraft and know the essential sensors and actuators, as well as their areas of use in space flight. |       |           |       |
| 10-I=AA | lecture | Advanced Automation          | 8   | Prof. Nüchter | W     |
|       | contents: | Advanced topics of automation systems and instrumentation and control engineering, for example from the field of sensor data processing, actuators, cooperating systems, mission and trajectory planning.  
|       | intended learning outcomes: | The students have advanced knowledge about selected topics of automation systems. They are able to realize advanced automation systems. |       |           |       |
| 10-I=3D | lecture | 3D Point Cloud Processing   | 5   | Prof. Nüchter | S     |
|       | contents: | Laser scanning, Kinect and camera models, basic data structures (lists, arrays, oc-trees), calculating normals, k-d trees, registration, features, segmentation, tracking, applications for airborne mapping, applications to mobile mapping  
|       | intended learning outcomes: | Students understand the basic principles of all aspects of 3D point cloud processing and are enabled to talk to engineers / surveyors / CV-people. Students can solve problems of modern sensor data processing and have experienced that real application scenarios are challenging, in terms of computational requirements, in terms of memory requirements, in terms of implementation issues |       |           |       |
### Contents:

**Databases 2**

- Data warehouses and data mining; XML databases; web databases; introduction to Datalog

**Computational Geometry**

- In many areas of Computer Science -- for example robotics, computer graphics, virtual reality and geographic information systems -- it is required to store, analyze, create or manipulate spatial data. This class is about the algorithmic aspects of these tasks: we will learn techniques that are needed to plan and analyze geometric algorithms and data structures. Every technique will be illustrated by a problem of the formerly mentioned practical areas.

**Approximation Algorithms**

- The task of finding the optimal solution for a given problem is omnipresent in computer science. Unfortunately, there exist many problems without an efficient algorithm for an optimal solution. As a result, in practice, methods are used which do not always give the optimal but always good solutions. In this lecture we will handle drafting and analyzing techniques for algorithms which have a proven approximation quality. Important drafting techniques include greedy, local search, scaling and methods based on linear programming are being presented by means of practical optimization problems.

**Visualization of Graphs**

- We handle the most important algorithms to draw graphs. Methods from the course Algorithmic Graph Theory like divide and conquer, flow-networks, integer programming and the planar separator theorem are being used. We will learn measures of quality of a graph drawing and algorithms to optimize these measures.

**Algorithms for Geographic Information Systems**

- Algorithmic foundations of geographic information systems and their application in selected problems of acquisition, processing, analysis and presentation of spatial information. Processes of discrete and continuous optimization. Applications like the creation of digital height models, working with GPS trajectories, tasks of spatial planning as well as cartographic generalization.

**Performance Engineering & Benchmarking of Computer Systems**

- Introduction in performance engineering of commercial software systems, performance measurement techniques, benchmarking of commercial software systems, modelling for performance prediction, case studies.

**Software Architecture**

- n. a.

### Intended Learning Outcomes:

**Databases 2**

- The students have advanced knowledge about Relational Databases, XML, and Data Mining.

**Computational Geometry**

- The students are able to decide which algorithms or data structures are suitable to solve a given geometric problem. The students are able to analyze new problems and to come up with their own efficient solutions based on the concepts and techniques learned in the lecture.

**Approximation Algorithms**

- The students are able to analyze easy approximation methods by their quality. They understand basic design techniques such as greedy, local search, scaling as well as methods that are based on linear programming and are able to apply these to new problems.

**Visualization of Graphs**

- The participants will receive an overview of the subject graph visualization and the usual tools therein. They will expand their knowledge of modeling and solving problems using graphs and graph algorithms.

**Algorithms for Geographic Information Systems**

- The students are able to formalize algorithmic problems in the field of geographic information systems as well as selecting and improving suitable approaches to solving the problem.

**Performance Engineering & Benchmarking of Computer Systems**

- The students possess basic and applicable knowledge in the area of performance metrics, measurement techniques, multi factorial variance analysis, data analysis with R, benchmark approaches, modelling with queue networks, modelling methods, resource demand approximation, petri networks.

**Software Architecture**

- n. a.

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<tr>
<td>10-I=DB2</td>
<td>lecture</td>
<td>Databases 2</td>
<td>5</td>
<td>Prof. Seipel</td>
<td>S</td>
</tr>
</tbody>
</table>

*intended learning outcomes:*

- The students have advanced knowledge about Relational Databases, XML, and Data Mining.

| 10-I=AG    | lecture | Computational Geometry                       | 5   | Prof. Wolff  | W     |

*intended learning outcomes:*

- The students are able to decide which algorithms or data structures are suitable to solve a given geometric problem. The students are able to analyze new problems and to come up with their own efficient solutions based on the concepts and techniques learned in the lecture.

| 10-I=APA   | lecture | Approximation Algorithms                     | 5   | Prof. Wolff  | S/W   |

*intended learning outcomes:*

- The students are able to analyze easy approximation methods by their quality. They understand basic design techniques such as greedy, local search, scaling as well as methods that are based on linear programming and are able to apply these to new problems.

| 10-I=VG    | lecture | Visualization of Graphs                      | 5   | Prof. Wolff  | S     |

*intended learning outcomes:*

- The participants will receive an overview of the subject graph visualization and the usual tools therein. They will expand their knowledge of modeling and solving problems using graphs and graph algorithms.

| 10-I=AGIS  | lecture | Algorithms for Geographic Information Systems | 5   | Prof. Wolff  | S     |

*intended learning outcomes:*

- The students are able to formalize algorithmic problems in the field of geographic information systems as well as selecting and improving suitable approaches to solving the problem.

| 10-I=PEB   | lecture | Performance Engineering & Benchmarking of Computer Systems | 5   | Prof. Kounev | S     |

*intended learning outcomes:*

- The students possess basic and applicable knowledge in the area of performance metrics, measurement techniques, multi factorial variance analysis, data analysis with R, benchmark approaches, modelling with queue networks, modelling methods, resource demand approximation, petri networks.

| 10-I=SAR   | lecture | Software Architecture                         | 5   | Prof. Kounev | S     |

*intended learning outcomes:*

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<tr>
<td>10-I=APR</td>
<td>lecture</td>
<td>Advanced Programming</td>
<td>5</td>
<td>Prof. Kounov</td>
<td>W</td>
</tr>
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</table>

**contents:**
- n. a.

**intended learning outcomes:**
- n. a.

| 10-I=STM  | lecture | Natural Language Processing and Text Mining | 5    | Prof. Hotho   | W      |

**contents:**
- Foundations in the following areas: definition of NLP and text mining, properties of text, sentence boundary detection, tokenization, collocation, N-gram models, morphology, hidden markov models for tagging, probabilistic parsing, word sense disambiguation, term extraction methods, information extraction, sentiment analysis.

**intended learning outcomes:**
- The students possess theoretical and practical knowledge about typical methods and algorithms in the area of text mining and language processing. They are able to solve practical problems with the taught methods. They gained experience in the application of text mining algorithms.

| 10-I=IR   | lecture | Information Retrieval                      | 5    | Prof. Hotho   | S      |

**contents:**
- IR models (e.g. boolean and vectorspace model, evaluation), processing of text (tokenizing, text properties), data structures (e.g. inverted index), query elements (e.g. Query operations, relevance feedback, query languages and paradigms, structured queries), search engine (e.g. Architecture, crawling, interfaces, link analysis), methods to support IR (e.g. Recommendation systems, text clustering and classification, information extraction)

**intended learning outcomes:**
- The students possess theoretical and practical knowledge in the area of information retrieval and receive the technical know-how to create a search engine.

| 10-HCI-RIS | lecture | Real-time Interactive Systems              | 5    | Prof. Latoschik | W      |

**contents:**
- This course provides an introduction into the requirements, concepts, and engineering art of highly interactive human-computer systems. Such systems are typically found in perceptual computing, Virtual, Augmented, Mixed Reality, computer games, and cyber-physical systems. Lately, these systems are often termed Real-Time Interactive Systems (RIS) due to their common aspects.

The course covers theoretical models derived from the requirements of the application area as well as common hands-on and novel solutions necessary to tackle and fulfill these requirements.

- The first part of the course will concentrate on the conceptual principles characterizing real-time interactive systems. Questions answered are: What are the main requirements? How do we handle multiple modalities? How do we define the timeliness of RIS? Why is it important? What do we have to do to assure timeliness? The second part will introduce a conceptual model of the mission-critical aspects of time, latencies, processes, and events necessary to describe a system’s behavior. The third part introduces the application state, its requirements of distribution and coherence, and the consequences these requirements have on decoupling and software quality aspects in general. The last part introduces some potential solutions to data redundancy, distribution, synchronization, and interoperability.

Along the way, typical and prominent state-of-the-art approaches to reoccurring engineering tasks are discussed. This includes pipeline systems, scene graphs, application graphs (aka field routing), event systems, entity and component models, and others. Novel concepts like actor models and ontologies will be covered as alternative solutions. The theoretical and conceptual discussions will be put into a practical context of today’s commercial and research systems, e.g., X3D, instant reality, Unity3D, Unreal Engine 4, and Simulator X.

**intended learning outcomes:**
- After the course, the students will have a solid understanding of the boundary conditions defined by both, the physiological and psychological characteristics of the human users as well as by the architectures and technological characteristics of today’s computer systems. Participants will gain a solid understanding about what they can expect from today’s technological solutions. They will be able to choose the appropriate approach and tools to solve a given engineering task in this application area and they will have a well-founded basis enabling them to develop alternative approaches for future real-time interactive systems.
This module will give students the opportunity to learn about the specificities of 3D User Interfaces (3DUI) development using Virtual, Augmented or Mixed Reality technologies. The module content will be mainly dedicated to learn and practice the skills essential to the design and implementation of high-quality 3D interaction techniques. Design guidelines as well as classical and innovative 3D Interaction techniques will be studied. In addition, the course will address novel research themes such as 3D interaction for large displays and games; and integrating 3DUIs with mobile devices, robotics, and the environment.

Students will be assessed through a group practical project (team work), which will consist of 3D Interaction Techniques (ITs) development for a particular task.

**intended learning outcomes:**

After the course, the students will gain a solid background on the theory and the methods to create your own 3D spatial interfaces. They will have a broad understanding of the particular difficulties of designing and developing spatial interfaces, as well as evaluating them. Students will also learn about traditional and novel 3D input/output devices (e.g., motion tracking system and Head-mounted Display).

### Multimodal Interfaces

The multimodal interaction paradigm simultaneously uses various modalities like speech, gesture, touch, or gaze, to communicate with computers and machines. Basically, multimodal interaction includes the analysis as well as the synthesis of multimodal utterances. This course concentrates on the analysis, i.e., the input processing. Input processing has the goal to derive meaning from signal to provide a computerized description and understanding of the input and to execute the desired interaction. In multimodal systems, this process is interleaved between various modalities and multiple interdependencies exist between simultaneous utterances necessary to take into account for a successful machine interpretation.

In this course, students will learn about the necessary steps involved in processing unimodal as well as multimodal input. The course will highlight typical stages in multimodal processing. Using speech processing as a primary example, they learn about:

1. A/D conversion
2. Segmentation
3. Syntactical analysis
4. Semantic analysis
5. Pragmatic analysis
6. Discourse analysis

A specific emphasis will be on stages like morphology and semantic analysis. Typical aspects of multimodal interdependencies, i.e., temporal and semantic interrelations are highlighted and consequences for an algorithmic processing are derived. Prominent multimodal integration (aka multimodal fusion) approaches are described, including transducers, state machines, and unification.

**intended learning outcomes:**

After the course, the students will be able to build their own multimodal interfaces. They will have a broad understanding of all the necessary steps involved and will know prominent algorithmic solutions for each of them. Student will learn about available tools for reoccurring tasks and their pros and cons.
Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, machine learning has given us practical speech recognition, effective web search, self-driving cars, and a vastly improved understanding of the human genome. Machine learning is so pervasive today that you probably use it dozens of times a day without knowing it. It is one of today’s prominent paradigms in HCI applicable in all areas where the understanding of user input of high variability, specifically for natural interactions using, e.g., gesture, speech, or eye-gaze, is paramount. Many researchers also think it is the best way to make progress towards human-level AI.

In this course, students will learn about the most effective machine learning techniques, and gain practice implementing them and getting them to work. Students not only learn the theoretical underpinnings of learning, but also gain the practical know-how needed to quickly and powerfully apply these techniques to new problems. Finally, they learn about some of Silicon Valley's best practices in innovation as it pertains to machine learning and AI.

This course provides a broad introduction to machine learning, data-mining, and statistical pattern recognition. Topics include: (i) Supervised learning (parametric/non-parametric algorithms, support vector machines, kernels, neural networks). (ii) Unsupervised learning (clustering, dimensionality reduction, recommender systems, deep learning). (iii) Best practices in machine learning (bias/variance theory; innovation process in machine learning and AI). The course will also draw from numerous case studies and applications, so that you’ll also learn how to apply learning algorithms to building gesture-based and multimodal interfaces, text and speech understanding (web search, anti-spam), smart robots (perception, control), computer vision, medical informatics, audio, database mining, and other areas.

**intended learning outcomes:**
After the course, the students will be able to solve machine learning tasks on their own using assistive technologies, e.g., like Octave. In addition, they will be able to derive main principles and apply these in own programs. Students will be able to choose the appropriate approach and tools to solve a given machine learning task in various application area, specifically in HCI.

**10-i=ST lecture** Discrete Event Simulation 8 Prof. Tran-Gia S

**contents:**
Introduction in simulation techniques, statistical groundwork, creation of random numbers and random variables, random sample theory and estimation techniques, statistical analysis of simulation values, inspection of measured data, planning and evaluation of simulation experiments, special random processes, possibilities and limits of model creation and simulation, advanced concepts and techniques, practical execution of simulation projects.

**intended learning outcomes:**
The students possess methodic knowledge and the practical skills for stochastic simulation of (technical) systems, for evaluation of results and for the correct assessment of possibilities and limits of simulation methods.

**10-i-RK lecture** Computer Networks and Communication Systems 8 Prof. Tran-Gia W

**contents:**

**intended learning outcomes:**
The students possess intricate knowledge about the structure of computer networks and communication systems, as well as about basic principles to rate these systems.
Selected chapters of computer communication, for example

- design aspects of future internet structures: setup and control structures of the internet, multicast protocols, protocols for multimedia communication, optical networks, control mechanisms for redundant and real time communication networks, p2p networks, ad-hoc networks,

- or new concepts and technologies in mobile communication: digital modulation, signal propagation, channel coding, modern transmission technologies (adaptive modulation and coding, hybrid ARQ, OFDM, MI-MO), mac layer, mobileIP, routing in ad-hoc networks, vertical handover, UMTS ip multimedia subsystem,

- or planning and management methods in telecommunication networks: planning methods (forward engineering, reverse engineering), network management paradigms (central and decentral), framework for network management (IETF traffic engineering, ITU-T TMN, OSI-management), planning and management methods (IP management mechanisms, network design, measurement, acquisition and evaluation of traffic and performance data, visualization, result handling, simulation and analysis of networks), management tools, outlook and perspectives,

- or other current topics.

**intended learning outcomes:**
The students have knowledge about advanced and current topics from the area of management and design of modern wired and wireless communication systems.