KV PROPAEDEUTIC

General competences

Objectives

Principles of computer science, its concepts, methods, and applications. Overview of the bachelor and masters program in computer science at JKU

Students

gain an understanding of career opportunities and major challenges

understand the basics of the CS curriculum at JKU

acquire basic familiarity with the thinking processes and concepts of software development beyond programming

acquire basic understanding on a range of accompanying topics (e.g., HCI design, requirements engineering)

Subject

The model-driven engineering course covers the CS curriculum and basic computer science concepts, such as loops or conditions, without presenting programming languages or presuming programming skills. The course mainly covers thinking processes a software engineer should have, from program tracing to problem solving.

Criteria for evaluation

Attendance, homework, and participation in the mentoring program

UE ALGEBRA FOR COMPUTER SCIENCE

General competences

Objectives

Autonomous solution of given problems, presentation of the results.

Subject

See the lecture.

Criteria for evaluation

Correctness of the presented solutions, clarity of exposure, ability to solve related problems independently. Presentation of homework problems on the blackboard. Written tests.

Methods

Presentation of the solutions of weekly assignments by the students.

VL ALGEBRA FOR COMPUTER SCIENCE

General competences

Objectives

Students master the operations of vector algebra, linear algebra and matrix calculations and can use these operations to model and solve geometric problems. They are able to compute the greatest common divisor in polynomial rings over fields and in the ring of integers, and they can perform the fundamental operations of some algebraic structures used in coding theory and cryptology, such as finite fields.

Subject

Linear Algebra

Vectors and Matrices in modelling geometric problems

Systems of linear equations

Projective geometry and homogeneous coordinates

Vector spaces

Linear mappings and their matrix representations

Determinants

Abstract algebra

Extended Euclidean gcd-algorithm in the integers and in univariate polynomial rings over fields.

Finite fields, construction from polynomial rings, arithmetic, properties.

Linear Codes

Criteria for evaluation

General: Understanding and mastery of the presented solution methods. Acquaintance with the underlying theory and its logical structure. Knowledge and presentation of the proofs contained in the lecture. Correct derivation of methods for solving related problems. Specifically: Written exam.

Methods

Lecture

UE ANALYSIS FOR COMPUTER SCIENCE

General competences

Objectives

The course focuses on understanding the most important base-knowledge concepts pertaining to analysis. Students will learn to apply methods to the field of analysis and address academic, scientific and technical topics. Autonomous solution of given problems, presentation of the results.

Subject

See the lecture.

Criteria for evaluation

General criteria: Correctness and clarity of the presented solutions, ability to solve related problems independently; Concrete evaluation: blackboard examples, exercise test

Methods

Presentation of weekly exercises at the blackboard. Discussion about the quality and their possible improvements.

VL ANALYSIS FOR COMPUTER SCIENCE

General competences

Objectives

The students get the ability to become acquainted with a deep mathematical theory, more precisely with the classical theory of real functions in one variable. In doing so, the participants get a fundamental understanding of the different working techniques and tactics in analysis. In particular, the already learned proving capabilities are deepened. The analysis is a central ingredient in the technical sciences. Basic knowledge will be learned in order to guarantee an effective collaboration with engineers in industry. In the lecture the students will learn important tools that are relevant, e.g., for the analysis of algorithms (best case, worst case, average case) or that play an important role, e.g., in computer graphics.

Subject

Real numbers and their computability, sequences and series, power series and the definition/computation of non-trivial functions, continuous functions, differential and integral calculus.

Criteria for evaluation

One written exam beginning of February, one extra exam end of February (the dates will be fixed at the first lectures based on the needs of the students)

Methods

Blackboard lecture together with detailed lecture notes.

UE COMPUTABILITY AND COMPLEXITY

General competences

Objectives

The exercise classes are designed to underpin important concepts from the lecture with practical, hands-on experience. The students will learn how to apply complexity-theoretic arguments to reason about concrete problems. We shall also use the exercise classes to discuss modern implications of computational complexity to other scientific disciplines (e.g. physics, math and politics).

Subject

See lecture

Criteria for evaluation

Biweekly homework exercises and quizzes (Moodle)

Methods

Written homework exercises

VL COMPUTABILITY AND COMPLEXITY

General competences

Objectives

Computers have been developed to, well, compute things. But not all computational tasks are equally difficult. Some are easy (e.g. multiplying two large prime numbers), while others appear to be much harder (e.g. factorizing a product of two large prime numbers). In this introductory course for theoretical computer science, the students learn how to appropriately formalize questions about computability (can we actually compute "something"?) and computational complexity (how hard is it to compute "something"?). A firm grasp of these concepts will allow students to gauge whether a given computational task is easy, or likely to be prohibitively challenging. Finally, we will also discuss the potential impact of quantum computers on the landscape of (classical) complexity theory.

Subject

Topics to be covered:

finite state automata

Turing machines

uncomputable functions & the Halting Problem

the problem class P ("problems that are easy to solve")

the problem class NP ("problems whose solution can be easily checked")

reductions and NP-completeness

SAT (satisfiability) & the Cook-Levin Theorem

coNP and the polynomial hierarchy

factoring, discrete logarithm & graph isomorphism ("important problems where we don't know if they are actually hard")

quantum computers as potential game changers

Criteria for evaluation

Written exam

Methods

Blackboard presentation

UE DISCRETE STRUCTURES

General competences

Objectives

Students solve examples autonomously and present their achieved results.

Subject

see the lecture

Criteria for evaluation

General: Correctness of the presented solutions, clarity of exposition, capability to solve related problems independently, participation in discussions. In particular: weekly homework problems, tests, possibly lab exercises.

Methods

Weekly homework assignments, autonomous work, teamwork, presentation, discussion.

VL DISCRETE STRUCTURES

General competences

Objectives

Students posses knowledge about the foundations of discrete structures in mathematics and computer sciences. They are familiar with the presented concepts and mathematical models. They are able to apply them autonomously in examples and case studies.

Subject

Foundations: basic principles of logic and set theory; relations and their properties, in particular orderings and equivalenzes, partitions; functions and properties like monotonicity, boundedness, being injective/surjective/bijective; operations on functions (composition, inverse); real functions, sequences.

Basics from "Numbers and Counting": natural numbers, integers, rational, and real numbers; (complete) induction; recursion (definition, solution strategies); combinatorics (permutations, binomial coefficients); applications.

Basic algebra: elementary number theory, arithmetic in Z and Zn (greatest common divisor, least common multiple), Euclidean algorithm; prime numbers, congruences and residue class systems, groups, rings and finite fields, application examples.

Graphs: directed and undirected graphs; paths, cycles, connectivity, connected components; isomorphic graphs; trees; applications.

Criteria for evaluation

General: knowledge, understanding, and application of presented contents; knowledge, familiarity, and application of proposed concepts and methods. Specifically: Written exam.

Methods

Slide presentation as well as discussion and examples on the blackboard.

UE FORMAL MODELS

General competences

Objectives

Students possess knowledge of formal methods to model and specify systems in computer science. After this course, students are able to

understand system descriptions based on formal models

concisely describe sytstems with formal models

solve simple verification and planning problems with formal models

Subject

The content is in accordance with the corresponding lecture:

Reactive systems

finite state machines

Petri nets

process algebra

temporal logics

bounded model checking

Markov decision processes

Criteria for evaluation

Multiple small tests and presentations of exercises or exam over the full course content (both jointly with the lecture).

Methods

Presentation of exercises by students. Moodle self-assessments.

VL FORMAL MODELS

General competences

Objectives

Students possess knowledge of formal methods to model and specify systems in computer science. After this course, students are able to

understand system descriptions based on formal models

concisely describe sytstems with formal models

solve simple verification and planning problems with formal models

Subject

reactive systems

finite state machines

Petri nets

process algebra

temporal logics

bounded model checking

planning

Markov decision processes

Criteria for evaluation

Multiple small tests and presentations of exercises or exam over the full course content (both jointly with the corresponding exercise class).

Methods

Slide-based presentation plus exercises.

UE LOGIC

General competences

Objectives

The students know how to use logic as a working language and they have the ability to compute with logic. After this course students are able to

understand definitions of logical languages (syntax and semantics)

calculate the truth values of logical formulas

understand laws and rules of logical languages and apply them to simplify formulas in a truth-preserving manner

apply rules of proof systems

work with various background theories

encode and solve simple questions of artificial intelligence and formal verification with logic

use different automatic provers and solvers

Subject

Propositional logic, predicate logic, satisfiability, SAT, SMT, DPLL, resolution, proof calculus, skolemization, normal forms, decidability.

Criteria for evaluation

Weekly minitests or one exam over the full content of the course (both are together with the lecture).

Methods

Exercises which are presented by the lecturers. Practical exercises which have to be solved with logic tools.

VL LOGIC

General competences

Objectives

The students know how to use logic as a working language and they have the ability to compute with logic. After this course students are able to

understand definitions of logical languages (syntax and semantics)

calculate the truth values of logical formulas

understand laws and rules of logical languages and apply them to simplify formulas in a truth-preserving manner

apply rules of proof systems

work with various background theories

encode and solve simple questions of artificial intelligence and formal verification with logic

use different automatic provers and solvers

Subject

Propositional logic, predicate logic, satisfiability, SAT, SMT, DPLL, resolution, proof calculus, skolemization, normal forms, decidability.

Criteria for evaluation

Weekly minitests with small weekly exercises optional projects

or

one exam over the full content of the course (both are together with the exercise).

Methods

Slide-based presentation plus practical examples and tool demos .

UE STATISTICS

General competences

Objectives

Students can analyze data using basic descriptive and inductive statistical methods. Students can interpret statistical methods and results in other work. They can also perform statistical analyses using the program package R.

Subject

gaining a deeper understanding of the methods of descriptive and inductive statistics as presented in the corresponding lecture

introduction into the program package R

Criteria for evaluation

weekly homework assignments and in-class presentation of these assignments

Methods

weekly homework assignments

in-class presentation and discussion of the homework assignments

live-coding in R

VL STATISTICS

General competences

Objectives

Students can apply basic methods of descriptive and inductive statistics on their own. They can analyze data using these methods and can interpret statistical methods and results in other work.

Subject

descriptive statistics:

graphical methods for presenting data

tables as tool to present data

summary statistics for location and variation

summary statistics for bivariate data

simple linear regression

introduction to probability theory:

combinatorics

probability according to Laplace

conditional probability and Bayes' theorem

random variables

important distributions in statistics (binomial distribution, hypergeometric distribution, Poisson distribution, normal distribution, chi-square distribution, t-distribution, F-distribution)

inductive statistics:

point estimation of parameters

confidence intervals for means and proportions

introduction to statistical test theory (t-test family, chi-square test, Fisher's exact test)

Criteria for evaluation

exam at the end of semester

Methods

lecture by instructor

UE DIGITAL SIGNAL PROCESSING

General competences

Objectives

Students know and understand the basics of analog as well as discrete-time signals and systems qualitatively and mathematically and can apply them to fundamental problems. They are able to

plot signals in time- and frequency domain,

explain the sampling theorem,

apply the convolution operation,

derive the spectrum of a signal numerically with the help of the DFT and the FFT,

describe the behavior of discrete-time LTI systems in time- and frequency domain,

analyze and design digital FIR and IIR filters, and

apply the correlation operation.

Students know and understand the basics of adaptive filters, and the basics of time-frequency analysis.

Subject

Basics of Analog Systems Theory

Discrete Time Signals Fundamentals

Discrete Time LTI Systems Fundamentals

Fourier Transform of Discrete Time Signals (DTFT)

Sampling and Reconstruction

Correlation

Spectral Analysis of Discrete Time Signals (DFT, FFT, Short Time Fourier Transformation, Applications)

z Transform

Digital Filters (FIR, IIR)

Vector Matrix Representations of Discrete Time Signals and LTI Systems

Adaptive Filters

Criteria for evaluation

Homework to be uploaded and evaluated

Methods

Demonstration of examples

Matlab examples

Homework

VL DIGITAL SIGNAL PROCESSING

General competences

Objectives

Students know and understand the basics of analog as well as discrete-time signals and systems qualitatively and mathematically and can apply them to fundamental problems. They are able to

plot signals in time- and frequency domain,

explain the sampling theorem,

apply the convolution operation,

derive the spectrum of a signal numerically with the help of the DFT and the FFT,

describe the behavior of discrete-time LTI systems in time- and frequency domain,

analyze and design digital FIR and IIR filters, and

apply the correlation operation.

Students know and understand the basics of adaptive filters, and the basics of time-frequency analysis.

Subject

Basics of Analog Systems Theory

Discrete Time Signals Fundamentals

Discrete Time LTI Systems Fundamentals

Fourier Transform of Discrete Time Signals (DTFT)

Sampling and Reconstruction

Correlation

Spectral Analysis of Discrete Time Signals (DFT, FFT, Short Time Fourier Transformation, Applications)

z Transform

Digital Filters (FIR, IIR)

Vector Matrix Representations of Discrete Time Signals and LTI Systems

Adaptive Filters

Criteria for evaluation

Written Exam

Methods

Lecture using slides and blackboard, Matlab based presentations

UE DIGITAL CIRCUITS

General competences

Objectives

Students understand the structure and functionality of today's computing devices. They are able to encode data and to conduct computations in the established number formats. They are able to design circuits realizing simple applications such as arithmetic and control tasks. They understand how memory works and how, together with combinatorial circuits, this provides the basic components to computers. Students are eventually enabled to design and optimize various logic functions/operations and check their correctness.

Subject

Boolean Algebra

Combinatorial Circuits and their Synthesis

Arithmetic Circuits

Sequential Circuits

Finite State Machines

Design and Optimization Methods

Criteria for evaluation

Assessment of weekly exercise sheets. Team work possible.

Methods

exercises

VL DIGITAL CIRCUITS

General competences

Objectives

Students understand the structure and functionality of today’s computing devices. They are able to encode data and to conduct computations in the established number formats. They are able to design circuits realizing simple applications such as arithmetic and control tasks. They understand how memory works and how, together with combinatorial circuits, this provides the basic components to computers. Students are eventually enabled to design and optimize various logic functions/operations and check their correctness.

Subject

Boolean Algebra Combinatorial Circuits and their Synthesis Arithmetic Circuits Sequential Circuits Finite State Machines Design and Optimization Methods

Criteria for evaluation

written exam

Methods

lecture

UE ELECTRONICS

General competences

Objectives

Computer science students master the basics of electronics and can calculate simple electrical networks and design logic gates on the transistor level.

Subject

Examples will be calculated in the following areas of interest:

Electrical current (Ohm's law, charge, current, voltage)

Electrical circuits (sources, Kirchhoff's laws)

Resistor, capacitor, inductor

Diode and transistor (MOS-FET)

From the transistor to the logical gate

Criteria for evaluation

The number of correctly solved assignments including presentation performance of the solution during exercise units, written/oral exam at the end of the semester.

Methods

Exercise examples in the subject areas are demonstrated in the exercise hours and deepened using homework in self-study. The homework is to be handed in weekly, group work is not planned.

VL ELECTRONICS

General competences

Objectives

Computer science students master the basics of electronics. They are able to calculate simple electrical networks as well as design logic gates on the transistor level and differentiate between the implementation of different storage systems.

Subject

Overview of the course contents:

Electrical current (Ohm's law, charge, current, voltage)

Electrical circuits (sources, Kirchhoff's laws)

Resistor, capacitor, inductor

Diode and transistor (MOS-FET)

From the transistor to the logical gate

Memory (SRAM, DRAM, FLASH)

Criteria for evaluation

Written and/or oral exam at the end of the semester.

Methods

Discussion of slides and interactive examples using blackboard.

UE COMPUTER ARCHITECTURE

General competences

Objectives

The exercises illustrate the topics covered in the lecture by means of practical tasks and use cases.

Subject

Different views on computers

Assembler

Structure and Functionality: Hardware, Software

Machine Code

Processor

Components of the Processor

Pipelining

Memory Organization

Evaluation of Computers

Criteria for evaluation

Assessment of weekly exercise sheets. Team work is possible.

Methods

Exercises

VL COMPUTER ARCHITECTURE

General competences

Objectives

Students understand how software is described in a fashion that can be realized in terms of logic circuits. They are enabled to realize corresponding components in a hardware description language. They are able to run simple software/assembly code on their own implementation of a processor. They are able to optimize their processor through sequential control units, pipelining, co-processors, etc. They are able to evaluate the performances of the resulting processors. The are enabled to improve the memory usage of their processors.

Subject

Different views on computers

Assembler

Structure and Functionality: Hardware, Software

Machine Code

Processor

Components of the Processor

Alternative Processors

Pipelining

Memory Organization

Evaluation of Computers

Criteria for evaluation

Written Examination

Methods

Talks and Exercises

UE ALGORITHMS AND DATA STRUCTURES 1

General competences

Objectives

Students learn algorithmic thinking. They are able to apply the topics presented in the lecture in practice by designing and implementing algorithms in Java.

Subject

Topics are:

Complexity

Lists/Stacks/Queues

Recursion

backtracking

Trees

Heaps, Priority Queues

Sorting

Digital Sorting

Strings and Patterns

Random Numbers

Randomized Algorithms

Criteria for evaluation

Assessment of weekly assignments.

Methods

The content of the lecture is deepened by weekly assignments.

VL ALGORITHMS AND DATA STRUCTURES 1

General competences

Objectives

Students are able to think algorithmically. They know the basic static and dynamic data structures, the most important sorting and search algorithms, and the concepts of recursion and random numbers. Furthermore, they are able to analyze the complexity of algorithms with respect to runtime and memory requirements.

Subject Programming language is Java. Topics are:

Complexity

Lists/Stacks/Queues

Recursion

backtracking

Trees

Heaps, Priority Queues

Sorting

Digital Sorting

Strings and Patterns

Random Numbers

Randomized Algorithms

Criteria for evaluation

Exam at the end of term

Methods

Slide-based presentation

UE ALGORITHMS AND DATA STRUCTURES 2

General competences

Objectives

Students are able to apply the topics presented in the lecture in practice by designing and implementing algorithms in Java (LVA 340.31x, Computer Science) or Python (LVA 340.32x, Artificial Intelligence).

Subject Topics are:

Randomized Algorithms

Search Trees

Hashing

Distributed Hashing

Graphs

Social Graphs

Power Law/Epidemic Spread

Evolutionary Algorithms

Document Graphs

PRAM Algorithms

Criteria for evaluation

The content of the lecture is deepened by weekly assignments.

Methods

The content of the lecture is deepened by weekly assignments.

VL ALGORITHMS AND DATA STRUCTURES 2

General competences

Objectives

Students are familiar with the most important advanced algorithms and data structures such as searching based on trees and hashing. Additionally, they understand the principle of graphs and learn how to implement graph structures. Students know advanced graph algorithms for finding structure properties and for analyzing interaction patterns in community graphs. Additionally, they understand basic concepts of optimization using evolutionary and PRAM algorithms. Finally, they are able to create problem specific solutions, based on the knowledge, the transformation and the combination of approved algorithms.

Subject

The lecture is independent of programming languages. Topics are:

Randomized Algorithms

Search Trees

Hashing

Distributed Hashing

Graphs

Social Graphs

Power Law/Epidemic Spread

Evolutionary Algorithms

Document Graphs

PRAM Algorithms

Criteria for evaluation

Exam at the end of term

Methods

Slide-based presentation

PR PRACTICAL TRAINING IN SOFTWARE DEVELOPMENT 2

General competences

Objectives

Students know and master the essential parts of the Java class library according to the contents of this course. They have a good command of methods and techniques of object-oriented frameworks and are able to apply them. They are proficient in the design of complex application programs.

Subject

Multi-threading, reflection, graphical user interfaces (JavaFX), streaming, network programming, security, remote methods, JDBC, Web Services.

Criteria for evaluation

Assessment of programming projects, written test.

Methods

Lecture, program examples, weekly or bi-weekly programming projects.

UE SOFTWARE ENGINEERING

General competences

Objectives

This course practices software engineering principles, methods, and tools in a team through a class project. It is recommended to also take the Software Engineering VL course.

Students

understand major activities of the software development life cycle from requirements capture to design, traceability, and implementation/testing

acquire familiarity with software engineering tools such as for UML modeling or requirements capture

learn about communication and interacting within a team where each member has full responsibility over a part of the system

Subject

The software engineering course practices requirements engineering (functional and non functional), uml design modeling, project planning, and implementation/testing.

Criteria for evaluation

written exercises (team work and individual works); active participation throughout the semester

VL SOFTWARE ENGINEERING

General competences

Objectives

This course teaches the basic principles of software engineering beyond programming. We cover all life-cycle stages from requirements engineering, architecture, design, and implementation. And we explore the evolution of software systems, planning for reuse, ensuring software qualities, all the way to the human factors and costs.

Students

understand the major phases of the software development life cycle from requirements capture to maintenance

understand the fundamental methods and techniques of software engineering

are able to develop (aka design) a software system without resorting to programming as its main method

are able to design functional aspects of a software system by also considering non-functional requirements

Acquire familiarity with software engineering tools

Subject

The software engineering course covers requirements engineering, uml design modeling, project planning and cost estimation, software processes, design decisions, functional and non-functional aspects of a system, V&V, software maintenance and reuse.

Criteria for evaluation

exam

UE SOFTWARE DEVELOPMENT 1

General competences

Objectives

Students learn to apply the concepts learned in the lecture. They acquire practical experience in designing, implementing, testing and documenting programs. They also practice good programming style.

Subject

Problem-solving techniques

algorithmic thinking

fundamental programming concepts

data types

arrays

instructions

methods

input/output

classes

inheritance

interfaces

dynamic data structures

recursion

exception handling

threads

packages

stepwise refinement

documentation and programming style

Criteria for evaluation

Assessment of weekly programming exercises. Mid-term and final test.

Methods

The contents of the lecture is deepened by examples and exercises. By working on weekly programming assignments, which are discussed after submission, students acquire practical programming skills.

VL SOFTWARE DEVELOPMENT 1

General competences

Objectives

Students are proficient in basic programming skills and algorithmic thinking. They are familiar with the Java programming language and have a good command of the concepts conveyed in the course such as recursion, dynamic data structures, exception handling and threading. They understand the basics of object-oriented programming and are able to design and implement simple object-oriented programs.

Subject

Problem-solving techniques

algorithmic thinking

fundamental programming concepts

data types

arrays

instructions

methods

input/output

classes

inheritance

interfaces

dynamic data structures

recursion

exception handling

threads

packages

stepwise refinement

documentation and programming style

Criteria for evaluation

Written exam at the end of the semester

Methods

Slide presentations with examples on the blackboard

UE SOFTWARE DEVELOPMENT 2

General competences

Objectives

Students are able to put the concepts learned in the lecture into practice. They have practice in object-oriented thinking, in the design and implementation of flexible and extensible software systems, and in the use of modern techniques of software development and software testing. They also have practice in the use of the Java class library.

Subject

Object-oriented thinking

classes

inheritance

dynamic binding

interfaces

genericity

lambda expressions

object-oriented design

modeling with UML

object-oriented frameworks

class libraries

design patterns

programming by contract

software testing

Criteria for evaluation

Assessment of weekly programming assignments; written test at the end of the semester

Methods

The contents of the lecture are deepened by examples. By working on weekly programming assignments, which are discussed after submission, students acquire practical skills in designing and implementing object-oriented software architectures.

VL SOFTWARE DEVELOPMENT 2

General competences

Objectives

Students become familiar with advanced software development techniques. They are able to design and implement non-trivial software systems according to object-oriented aspects and to use modern software concepts such as interfaces, genericity, lambda expressions, design patterns and frameworks. They are familiar with systematic software testing methods and formal correctness considerations.

Subject

Object-oriented thinking

classes

inheritance

dynamic binding

interfaces

genericity

lambda expressions

object-oriented design

modeling with UML

object-oriented frameworks

class libraries

design patterns

programming by contract

software testing

Criteria for evaluation

Written exam at the end of the semester

Methods

Slide presentations with examples on the blackboard. By working on weekly programming assignments, which are discussed after submission, students acquire practical programming skills.

UE SYSTEMS PROGRAMMING

General competences

Objectives

Understanding programming on the lowest respectively a very low level of a computer. Participants understand pointers and manual memory reservation, use, and release. Students are able to read and understand assembler code and write simple assembly programs. Students can read, understand, and write C programs.

Subject C Programming:

operators

statements

pointers

arrays

strings

user-defined types

memory management

standard library (basics)

Criteria for evaluation

Total number of points achieved in Moodle quizzes, and homework submissions. No final exam.

Methods

hands-on homework exercises with online guidance with opportunity for discussion and questions in the forum and in the course classes

VL SYSTEMS PROGRAMMING

General competences

Objectives

Understanding programming on the lowest respectively a very low level of a computer. Participants understand pointers and manual memory reservation, use, and release. Students are able to read and understand assembler code and write simple assembly programs. Students can read, understand, and write C programs.

Subject C Programming:

operators

statements

pointers

arrays

strings

user-defined types

memory management

standard library (basics)

Criteria for evaluation

Moodle exam at the end

Methods

Lecture accompanied by practical exercises (separate course) and online support with opportunity for discussion and questions in the forum.

Lecture in German, with English-language videos as a supplement

UE OPERATING SYSTEMS

General competences

Objectives

Students master important concepts of modern operating systems and system-oriented programming, which are reiterated from the lecture operating systems and extended by practical aspects.

Subject

Concepts of modern operating systems and system-oriented programming (e.g. scheduling and synchronization, memory management, file systems, virtualization)

Criteria for evaluation

Continuous evaluation of active participation, regular tests, and multiple home work assignments (non-weekly)

Methods

Presentation and discussion, independent solving of exercises

VL OPERATING SYSTEMS

General competences

Objectives

Students

acquire basic knowledge about the tasks, architecture, and methods of operating systems (vendor independent)

are familiar with specific algorithms for core operating system tasks such as scheduling and memory management

understand the relationship between different parts of operating systems (e.g. security measures)

understand how these concepts can be applied in deployed operating systems

Subject

Basics

relevant hardware functions

classification of operating sytems

memory management

processes

scheduling

parallelism

files and file systems

security

distributed systems

case studies of specific deployed operating systems

Criteria for evaluation

Written exam

Methods

Lecture with interactive elements

UE COMPILER CONSTRUCTION

General competences

Objectives

Students are able to put the concepts learned in the lecture into practice by implementing a full compiler. They master the description of translation processes by means of attributed grammars.

Subject

Students implement a full compiler for a Java-like language on a virtual machine. All parts of a compiler (scanner, parser, symbol table, type checking, code generation) are covered. They also acquire practice in using a compiler generator.

Criteria for evaluation

Assessment of programming assignments for the individual parts of the compiler. Assignments are given every 1-2 weeks.

Methods

In the lab, a full compiler is implemented. Its parts are written in weekly or bi-weekly assignments, which are explained before they are handed out and discussed after completion.

VL COMPILER CONSTRUCTION

General competences

Objectives

Students understand the structure and the workflow of compilers. They are familiar with common methods of scanning, parsing, symbol table handling (including type checking), and code generation and are able to implement a simple compiler. They can transfer compiler construction skills to general software engineering problems, eg, by using attributed grammars for general translation processes.

Subject

Basics of formal languages (regular and context-free grammars, deterministic finite automata, push-down automata), scanning, parsing (recursive descent, LR(1), LALR(1)), attributed grammars, symbol tables, code generation, virtual machines, compiler generators.

Criteria for evaluation

Written exam at the end of the semester.

Methods

Slide presentations as well as examples on the backboard.

UE COMPUTER NETWORKS

General competences

Objectives

Students acquire practical knowledge in the field of Ethernet, IPv4/6 and TCP. They gain a deeper understanding of basic network concepts.

Subject

as in the lecture

Criteria for evaluation

Submitted exercises and lab reports plus participation including presentation of results; intermediate tests + final written exam.

Methods

This exercise is the practical part of the lecture “VO Networks and Distributed Systems. It helps students deepen their understanding of some of the contents taught in the lecture. Students prepare exercise examples (typically on a weekly basis), their results are then discussed in the exercise lesson. In addition, several dates take place in the network lab, showing the behavior of selected protocols and configurations by testing in special environments.

VL COMPUTER NETWORKS

General competences

Objectives

Imparting basic network concepts on the basis of the ISO-7 layer model, TCP/IP and Ethernet. Getting to know the important tasks in distributed systems.

Based on the understanding of the interrelationships and the cooperation of protocols in the protocol stack, students can estimate communication requirements and thus better employ and select protocols. The lecture also provides an understanding of the general basic concepts of protocols, This is important for the design of communication applications and the adaptation / conception of network protocols.

Subject

General principles of protocols, TCP/IP- and ISO/OSI-7-layer model, structured cabling, data link layer incl. Ethernet and switching, network layer (routing, IPv4 and IPv6), TCP / MPTCP, NA(P)T and selected application layer protocols

Criteria for evaluation

written exam (knowledge & understanding)

Methods

lecture (+ additional exercises)

UE EMBEDDED AND PERVASIVE SYSTEMS

General competences

Objectives

Students will gain hands on experience with embedded systems in three workshops. Students are able to apply the topics presented in the lecture in practice in the form of assignments and a group project throughout the semester.

Subject

Introduction to Embedded Systems

Identification/Biosignals/Environmental Sensors

Localization/positioning/motion

Smart Phones/Communication/Actuators

Nonfunctional System Characteristics

Time/Time Models/Clock Synchronization

scheduling

Realtime

Concurrent Models of Execution

Energy Efficient Design

Criteria for evaluation

Assessment of group projects and weekly assignments. Mandatory attendance.

Methods

Workshops

Discussion of the assignments

Discussion, implementation and presentation of the group project

The programming language used in the workshops and project is Python.

VL EMBEDDED AND PERVASIVE SYSTEMS

General competences

Objectives

Students learn general classifications, characteristics and applications of embedded systems. They know different sensors, actuators, possibilities of localization and positioning as well as methods of digital communication. Furthermore, students are able to analyze nonfunctional system characteristics and realtime systems and implement schedulers and concurrent models.

Subject

Introduction to Embedded Systems

Identification/Biosignals/Environmental Sensors

Localization/positioning/motion

Smart Phones/Communication/Actuators

Nonfunctional System Characteristics

Time/Time Models/Clock Synchronization

scheduling

Realtime

Concurrent Models of Execution

Energy Efficient Design

Criteria for evaluation

Exam at the end of term

Methods

Slide-based presentation

UE MULTIMEDIA SYSTEMS

General competences

Objectives

Students will be able to use multimedia content in software applications. Students will develop competences in assessing components, architectures and trends of multimedia systems are going to be surveyed.

Subject

Provides an introduction to standards and formats of multimedia content from an application oriented point of view. Different types of media (text, graphic, audio, video) and their processing, their storing and their compression algorithms like MPEG or JPEG; multimedia formats, animations, digital or interactive television, architectures of multimedia systems.

Criteria for evaluation

Continuous evaluation of assignments which are handed out in different intervals due to the partially blockwise delivery of the course. The assignments can be done in teams.

VL MULTIMEDIA SYSTEMS

General competences

Objectives

students become familiar with the standards and formats of multimedia-based data. They know how to evaluate components, architecture and trends of multimedia systems.

Subject

Media types (text, graphic/image, audio, video)

compression methods (lossy and lossless)

stand-alone multimedia systems (multimedia storage formats, synchronization)

networked multimedia systems (multimedia streaming, QoS principles

and methods, digital TV)

Criteria for evaluation

Written exam without documents, questions concerning basic knowledge, practical skills and advanced understanding.

Methods

Lecture, self-study by deepening examples, questions, discussions

UE ARTIFICIAL INTELLIGENCE

General competences

Objectives

This exercise track accompanies the VL "Artificial Intelligence". Students deepen their understanding of the technical contents taught in the lectures preparing them for the final exam to the VL.

Subject

Exercises entail answering written questions as well as implementing selected algorithms to solve toy problems with a relation to real world problems. Students may optionally participate in a friendly challenge, writing intelligent software agents that compete in a tournament, to earn extra credit.

Criteria for evaluation

Points acquired through correct answers, correct implementations and optionally through challenge participation.

Methods

The class is taught through recurring meetings with general, collected feedback. Students solve regularly assigned exercises (about biweekly), and may optionally form teams and participate in an AI game bot competition.

VL ARTIFICIAL INTELLIGENCE

General competences

Objectives

Students know the basic concepts underlying and defining the field of Artificial Intelligence (AI), including its history, fundamental goals and assumptions, general approach to problem modeling, and selected algorithms; they will have a broad overview of the field that permits them to pursue more in-depth studies, via more advanced classes or self-study, and to critically evaluate the potential benefits and dangers of AI.

Subject

Definitions of AI. Problem solving as a search process: search algorithms (uninformed and heuristic), heuristic search in games. Knowledge representation and logical reasoning: inference in propositional logic. Reasoning with uncertain knowledge: knowledge representation and inference in Bayesian nets. Machine learning: inductive concept learning, reinforcement learning, learning about probabilities. Basics of computer perception.

Criteria for evaluation

Written exam at the end of the semester

Methods

Standard lectures with study materials (slides) provided.

UE COMPUTER GRAPHICS

General competences

Objectives

Computer graphics methods are essential for many areas, such as visual effects in movies, computer games, scientific and information visualization, and many others. In this course, participants will learn basic computer graphics techniques, and will understand the general concepts behind real-time and photo-realistic rendering. Besides the fundamental principles, this course will also provide a glance on modern approaches in computer graphics and visualization. A sufficient introduction into OpenGL with JavaScript and GPU shader programming are parts of the hands-on component of this class.

Subject

Transformations and projections, raster algorithms and depth handling, local shading and illumination, texture mapping basics, advanced texture mapping & graphics pipelines, basics of animation, introduction into graphics programming concepts such as GLSL.

Criteria for evaluation

Project (project presentations and results)

Methods

Slide presentation with case studies

VL COMPUTER GRAPHICS

General competences

Objectives

Computer graphics methods are essential for many areas, such as visual effects in movies, computer games, scientific and information visualization, and many others. In this course, participants will learn basic computer graphics techniques, and will understand the general concepts behind real-time and photo-realistic rendering. Besides the fundamental principles, this course will also provide a glance on modern approaches in computer graphics and visualization. A sufficient introduction into WebGL, GPU shader programming in CUDA, and visualization libraries, such as the Visualization Toolkit (VTK are parts of the hands-on component of this class.

Subject

Transformations and projections, raster algorithms and depth handling, local and global shading and illumination, texture mapping basics, advanced texture mapping & graphics pipelines and scene graphs, ray tracing and radiosity, volume rendering, scientific data visualization, curves and surfaces, basics of animation, introduction into graphics programming concepts such as WebGL, CUDA, and Visualization Toolkit (VTK).

Criteria for evaluation

midterm eExam (Moodle Test)

final eExam (Moodle Test)

Methods

Slide presentation

UE DATABASES AND INFORMATION SYSTEMS 1

General competences

Objectives

Students are able to apply the content taught in the lecture Databases and Information Systems 1. They have gotten experience to use lecture's content in examples that mostly are from real world. Students are well prepared for the lecture exam.

Subject

The same as in lecture Databases and Information Systems 1:

General aspects on architecture of database systems and data models

general steps of a database design

ER model

Relational Model including transformation of an ER-diagram into relational schemata

Relational Algebra and SQL

Relational Database Design

Transactions and Multi-user synchronization

Criteria for evaluation

Homework quality and quality of homework presentations. No exam at the end of the semester.

Methods

Students have to do homework on a weekly basis. In the class, selected students have to present their solution and this will be discussed with the whole group. Additionally, important topics from the lecture will be repeated and a look-ahead to the next homework will be given.

VL DATABASES AND INFORMATION SYSTEMS 1

General competences

Objectives

Students understand architecture and operating principles of database systems. They are able to model data at conceptual and logical level and are proficient in applying according to methodologies for that. They know formal query languages as well as in particular the structured query language SQL and can formulate complex queries. Additionally they know the theoretical foundations of the relational data model and the relational database design. They can apply it to real world situations. Furthermore, they understand transactions and first basics of multi user synchronization.

Subject

General aspects of database systems and data models

general steps of a database design

ER model

Relational Model including transformation of an ER-diagram into relational schemata

Relational Algebra and SQL

Relational Database Design

Transactions and Multi-user synchronization

Criteria for evaluation

Written exam at the end of the semester.

Methods

Standard lectures with study materials (slides) provided via KUSSS.

UE DATABASES AND INFORMATION SYSTEMS 2

General competences

Objectives

Graduates have practical knowledge of selected topics of the lecture. Concerning database concepts practical knowledge is gained by means of the DBS Oracle.

Subject

Stored procedures and trigger

object orientation and databases

XML technologies and databases

transactions

optimization

Criteria for evaluation

Exercises (submission every two weeks), oral participation

Methods

Slide presentations, discussion of new as well as finished exercises, exercise presentations by students. Course usually takes place every two weeks.

VL DATABASES AND INFORMATION SYSTEMS 2

General competences

Objectives

Graduates understand extended SQL language constructs as well as the basic concepts and techniques of object-relational (OR) and semi-structured (XML and JSON) data models and according to middleware approaches. They have in-depth knowledge about query (XQuery) and transformation (XSLT) languages based thereupon. Finally, they have expertise in physical database most notably transaction management and performance concepts tuning.

Subject

Advanced SQL concepts (referential actions, materialized views, OLAP queries, recursive queries, stored procedures and trigger);

Object-orientation and Databases (modeling, object-relational database concepts and mapping-middleware, JDBC);

XML technologies and databases (DTDs, XMLSchema, XPath, XMLAPIs, XSLT, XQuery, Storage of XML-documents, JSON);

Transaction mechanisms (Serializability, Recoverability, optimistic / pessimistic methods, extended transaction models);

Performance tuning mechanisms (Tuning principles, query optimization, algebraic optimization)

Criteria for evaluation

exam

Methods

slide-based lecture

VL INTRODUCTION TO MACHINE LEARNING

General competences

Objectives

Students should be able to explain the fundamental principles of machine learning and its applications in various fields such as signal processing, image processing, natural language processing, process modeling, and life sciences.

Students should be able to differentiate between different types of machine learning: supervised learning, unsupervised learning, and reinforcement learning.

Students should be able to explain and apply basic machine learning algorithms such as linear regression, k-means, nearest neighbor, and principal component analysis.

Students should be able to evaluate machine learning models using various metrics such as cross tabulation/contingency tables and ROC curves.

Students should be able to explain and utilize advanced methods such as support vector machines and random forests.

Students should acquire basic knowledge of neural networks and deep learning, and be able to program simple neural networks in Python using deep learning frameworks.

Students should critically reflect on the advantages and disadvantages of different machine learning techniques and their performance in real-world scenarios.

Students should be able to implement and adapt machine learning models using libraries such as Scikit-learn or TensorFlow.

Subject

Machine learning is concerned with creating predictive models and inferring relationships by learning from data. Machine learning methods have become indispensable in various fields, such as computer vision, signal processing, speech and language processing, process modeling, life sciences, and so forth. This course features the most essential concepts of machine learning and gives an overview of the most important methods. The methodological subjects are complemented by examples of exciting recent real-world applications of machine learning methods.

Taxonomy of machine learning: supervised vs. unsupervised learning, reinforcement learning, classification vs. regression

Examples of basic methods: nearest neighbor, linear regression, k-means, principal component analysis

Basics of evaluating machine learning models: confusion tables, ROC curves

Support vector machines and random forests (+ examples from life sciences)

Neural networks and deep learning (+ examples from image analysis, drug design, and language processing)

Clustering and biclustering

Criteria for evaluation

Written exam

Methods

Slide presentations complemented by online demos and examples presented on the blackboard. The lecture is also supported by a MOOC, providing videos, compact scripts, and exercises.

KV ETHICS AND GENDER STUDIES

General competences

Objectives

Students

are aware of social, ethical and gender relevant implications of new technologies

know crucial international policies and regulatory measures

Subject

Ethics

Introduction to ethical issues of technology research and development focusing on AI & robotics using current practical examples

Presentation and discussion of ethics-related codes of conduct for computer scientists (eg IEEE)

Content of current ethics guidelines and regulatory approaches (eg "Ethics Guidelines for Trustworthy AI "and related Policy Recommendations of the European Commission)

Reproduction of socialized stereotypes through data-driven AI, discussion of practical examples and possible counter-strategies

Gender

Introduction to gender and diversity from the point of view of neuroscience and neurodidactics

Presentation and discussion of aspects and questions on gender and diversity in technology and computer science (eg gender gap with respect to interest and learning outcomes, challenges for women in technical / IT occupations, different approaches of problem solving, different preferences, etc.)

Gender stereotypes - a grain of truth?

Self-concept as a key influencing factor on the gender gap in the field of computer science/technology

Gender neutrality - how should this work? Experiences from the project "Gender meets Informatics" - design of gender-neutral and gender-sensitive computer science lessons and materials for pupils and students

Addictive factors of online games (how do online games change the social behavior of children and adolescents, influence on cognitive development ...)

Ethics, gender and diversity in practice

Discussion of experiences and/or interests of students in the context of LVA topics

Implementation of smaller (empirical) projects on LVA topics in schools, universities and/or companies

Discussion of measures and strategies for the (future) handling of questions and problems around ethics, gender and diversity in computer science/technology

Criteria for evaluation

Short presentation, written paper, participation (examination), team work

Methods

Combination of presentation parts and interactive elements

Linkage of LVA-relevant theories, scientific-empirical literature and current practical examples

Project-based learning

Flipped classroom

Team work

KV GENDER STUDIES AND SOCIAL COMPETENCE

General competences

Objectives

This course aims to give students of information electronics, as well as science and engineering in general, an introduction to the research field "gender and / in computer science". It also aims at enabling students to reflect on the interrelationship between gender relations and technology development. It also aims at enhancing their gender competence as well as their social competence in general.

Subject

The results of gender research, especially concerning the field of computer science and the professions in the field of information and communication technologies. Didactics which recognizes the "diversity" of media biographies, styles of learning, and goals of learning.

Criteria for evaluation

Presence, participation, presentation and term paper.

Methods

Discussion of cutting edge theories of gender

Discussion of theories of knowledge production and feminist theories concerning the development of technology, especially computer science.

Reflection of research results concerning didactics in science and engineering and its contribution to sustain, reinforce or alter gender relations.

Social competence as an essential part of gender competence: practical exercises and reflection on presentation, communication and team work.

KV GENDER STUDIES TNF - INTRODUCTION

General competences

Objectives

Students gain insight into accounts of gender studies in science and technology development. They acquire important gender competence, which is indispensable for internationally recognized research, including science and engineering. The goal of this interdisciplinary course is to acquaint students in science and engineering with approaches of gender research in their specific areas. An analytically well-grounded insight in social gender relations enables students to understand, reflect and act responsibly within the specific gender structures of their disciplines.

Subject

The course gives an overview of central debates and results of gender studies in science and engineering. Topics of science and technological artifacts are analyzed regarding their meaning for gender relations. Theories as the co-production of gender and technology or science are introduced: How do social ideas about gender influence scientific theories and methods as well as technological development – and vice versa? Further, the course teaches the history of women scientists and engineers and offers epistemological and philosophical reflections of situated knowledge.

Criteria for evaluation

Attendance and participation in discussion; reading of the assigned literature; written exam on the content of the course at the end of the semester.

Methods

Research results are presented that unpack mechanisms and background assumptions of gender relations in science and engineering. Students are encouraged to pursue self-learning in this field. Several approaches to integrating aspects of gender and diversity in research and development in innovative ways will be discussed.

KS INTRODUCTION TO SOCIETY, GENDER AND DIVERSITY IN INFORMATION TECHNOLOGY

General competences

Objectives

The course introduces the concepts and theoretical approaches of Gender Studies. It presents relationships between Information and Communication Technologies and society and gender.

Subject

Concepts and theoretical approaches of Gender Studies, Women in Science and Information Technology, Gender in Science, Digital Divide, Gender, Work & Culture in ICT, Gender Mainstreaming and Diversity Management.

Criteria for evaluation

Attendance 50% of the course units, reading and participation in discussions about key literature, project exercise, exam

Methods

Presentation, reading and discussion of key literature, project exercise

KV PROJECT MANAGEMENT

General competences

Objectives

Students understand the theoretical foundations for the management of software projects. They can apply common methods for project planning, project control, and project tracking. Students are also able to use project management tools in a concrete project.

Subject

Foundations (key concepts, types of projects, forms of organization)

Project goals and requirements

process models

Risk assessment and risk management

Effort and cost estimation

Schedule and resource planning

Project tracking and project control

Project management tools

Criteria for evaluation

2-4 practical exercises as part of the semester project; written test at the end of the semester (summer semester); elaboration and presentation of a specialization topic (winter semester)

Methods

Presentation based on slides; Semester projects in teams; Discussion of new and joint review of project deliverables; discussions; Use of software tools

KV TECHNIQUES OF PRESENTATION AND TEAM WORK

General competences

Objectives

Students understand the foundations of the research process. They are able to systematically find and study scientific literature for a research question of their choice. They know how to assess different kinds of publications regarding their quality and topicality. Students gain experience in writing a scientific paper and in presenting and discussing the paper at a conference organized as part of the lecture.

Subject

research process

Definition of research questions for selected research areas

systematic literature search

scientific writing

presentation techniques

Criteria for evaluation

Formal and scientific quality of the submitted paper; quality of the presentation slides; presentation at the conference

Methods

Slide presentation with examples on the blackboard; teamwork; use of digital libraries; personal feedback on various milestones (research questions and outlines, draft, final paper, presentation slides); conference with talks by students

VL LAW FOR COMPUTER SCIENCE

General competences

Objectives

Confirmation of legal rules regarding computer programs and the Internet (substantive law only). Understand problem areas to be able to recognize, where legal advice must be obtained to avoid risks. Awareness of the relevance of legal aspects in software development, eg for copyright and licenses.

Subject

Copyright, domain names (name law, protection of registered marks and unfair competition), software patents, web sites (liability, information requirements), privacy law

Criteria for evaluation

Written Examination

Methods

Lecture and discussion of cases

VL ECONOMY FOR COMPUTER SCIENCE

General competences

Objectives Graduates have knowledge about basic economic concepts, methods and processes required for development, deployment, and management of IT applications, for the management of IT-focused departments and as a proper basis for enterprise start-ups in the IT sector. Complementary to that, graduates are in the position (i) to understand the different dimensions of digital transformation in the sense of digital business processes as well as digital production and service processes and their impact on companies ("Industry 4.0"), customers ("eBusiness") and employees ("Work 4.0") (ii) to know the wide spectrum of disruptive digital business models to foster the digital value creation process.

Subject

Enterprise planning, foundation and organization (business processes, business models, business plan, site plan, organization of enterprise structure and processes);

Management of personnel (planning, deployment, salaries, motivation, learning, knowledge management, group management, conflict management, leadership);

Marketing (sales planning, market development, marketing mix);

Accounting and finance (cash accounting, double bookkeeping, balance of accounts, income statement, cost account, controlling);

Digital Economy (Dimensions of digital transformation, disruptive business models, Customer 4.0, Industry 4.0, Work 4.0);

Guest lectures from industry: IT governance, IT support of management strategies, design of business plans, ERP systems, eBusiness/socialMedia – concepts/methods/applications).

Criteria for evaluation

exam

Methods

slide-based lecture

UE MACHINE LEARNING: UNSUPERVISED TECHNIQUES

General competences

Objectives

This practical course complements the lecture "Machine Learning: Unsupervised Techniques" and aims at practicing the concepts and methods acquired in the lecture.

Subject

Error models

information bottleneck

Maximum likelihood and the expectation maximization algorithm

Maximum entropy methods

Basic clustering methods, hierarchical clustering, and affinity propagation

Mixture models

Principal component analysis, independent component analysis, and other projection methods

Factor analysis

matrix factorization

Auto-associator networks and attractor networks

Boltzmann and Helmholtz machines

Hidden Markov models

Belief networks

Factor graphs

Criteria for evaluation

Assignments during the semester plus final exam

Methods

Students are given assignments in 1-2 week intervals. Homework must be handed in. Results are to be presented and discussed in the course.

VL MACHINE LEARNING: UNSUPERVISED TECHNIQUES

General competences

Objectives

Machine learning is concerned inferring models/relationships by learning from data. Machine learning methods are gaining importance in various fields, such as, process modeling, speech and image processing, and so forth. In recent years, bioinformatics has become one of the most prominent application areas of machine learning methods: The massive data amounts produced by recent and currently emerging high-throughput biotechnologies provide unprecedented potentials, but also pose yet unseen computational challenges in the analysis of biological data.

This course focuses on so-called unsupervised machine learning techniques, that is, methods aiming at inferring structure/models in data without an explicit target. The students should aquire skills to choose, use, and adapt methods for clustering, data projection, and data reduction for tasks in science and engineering. The students should particularly understand the underlying mathematical objectives and principles of unsupervised machine learning methods.

Subject

Error models

Maximum likelihood and the expectation maximization algorithm

Maximum entropy methods

Basic clustering methods, hierarchical clustering, and affinity propagation

Mixture models

Principal component analysis, independent component analysis, and other projection methods

Factor analysis

Matrix factorization

Auto-associator networks and attractor networks

Boltzmann and Helmholtz machines

Hidden Markov models

Belief networks

Factor graphs

Criteria for evaluation

Exam (written or oral)

Methods

Slide presentations complemented by examples presented on the blackboard

UE NATURAL LANGUAGE PROCESSING

General competences

Objectives

Natural Language Processing (NLP) is the study of how to understand and process human language using computational methods. The aim of the course is to provide in depth knowledge on the essential elements of NLP, particularly based on machine learning and neural networks. Through assignments, students gain the know-how to develop effective NLP solutions with machine learning and neural networks for tasks such as document classification and sentiment analysis.

Subject

The assignments cover the following topics:

Text processing

Sentiment analysis with machine learning and bag-of-word methods

Working with word embeddings

Document classification with PyTorch

Criteria for evaluation

Three assignments during the course, and one in-class workshop

Methods

Jupyter Notebook Assignments as well as one practice-oriented workshop.

VL NATURAL LANGUAGE PROCESSING

General competences

Objectives

Natural Language Processing (NLP) is the study of how to understand and process human language using computational methods. The aim of the course is to provide in depth knowledge on the essential elements of NLP, particularly based on machine learning and neural networks. Upon completing, students will be able to understand the mechanisms behind NLP systems, applied to applications such as language modeling, document classification, sentiment analysis, information retrieval, computational social science, and detection of societal biases. The students will be able to propose and weigh various solutions to NLP problems.

Subject

The course covers the following topics:

Text processing

Sentiment analysis with machine learning

Language modeling with neural networks

Word embedding models (word2vec, GloVe, etc.)

Learning compositional embeddings

Contextualized word embeddings (practical walkthrough)

Principles of Information Retrieval

Footprint of societal phenomena and biases in NLP

Criteria for evaluation

Written exam at the end of the semester

Methods

Slide presentations with examples on blackboard.

VL MACHINE LEARNING: ADVANCED TECHNIQUES

General competences

Objectives

Machine learning is concerned inferring models/relationships by learning from data. Machine learning methods are gaining importance in various fields, such as, process modeling, speech and image processing, and so forth. In recent years, bioinformatics has become one of the most prominent application areas of machine learning methods: The massive data amounts produced by recent and currently emerging high-throughput biotechnologies provide unprecedented potentials, but also pose yet unseen computational challenges in the analysis of biological data. Despite all potentials and successes of machine learning, one has to acknowledge that machine learning methods may produce poor or misleading results if they are applied inappropriately.

This course provides a look at the theoretical background of machine learning. The goal is to make students acquainted with the mathematical theories underlying machine learning methods in order to have a more profound understanding of the potentials and limits of machine learning.

Subject

Bias-variance decomposition

Estimation theory

Statistical learning theory

Worst-case and average bounds on the generalization error

Structural risk minimization

Theory of kernel methods

Causal interference

Criteria for evaluation

Exam (written or oral)

Methods

Slide presentations complemented by examples presented on the blackboard

UE PLANNING AND REASONING IN ARTIFICIAL INTELLIGENCE

General competences

Objectives

The aim of this course is to practically apply different kinds of formalisms to solve planning and reasoning tasks.

Subject

This exercise course covers symbolic reasoning techniques that are used in various application domains like planning or formal verification. Encodings of concrete application problems are realized to demonstrate strengths and limitations of the symbolic reasoning techniques.

Criteria for evaluation

In these exercises, the students realize small projects exploiting different symbolic AI technology and will use modern reasoning tools to implement the concepts presented in the lecture. The exercise performance is used as basis to assess the lecture performance too. Additional make-up exams covering both lecture and exercises are offered as well.

Methods

Q&A sessions / tutorials

Weekly exercises

Two encoding projects

Literature study/tool evaluation

VL PLANNING AND REASONING IN ARTIFICIAL INTELLIGENCE

General competences

Objectives

The aim of this course is understand and use different kinds of formalisms to solve planning and reasoning tasks.

Subject

This lecture covers symbolic reasoning techniques that are used in various application domains like planning or formal verification. The underlying theory of the applied formalims is introduced and the power of the inference mechanisms offered by these formalisms is analyzed. Encodings of concrete application problems demonstrate strengths and limitations of the symbolic reasoning techniques.

Criteria for evaluation

The evaluation is together with the exercise class and is based on:

Weekly online exercises

Projects in teams and presentations of the solutions

Short presentation of a recent topic related to the course

Alternatively, there is also an exam offered.

Methods

Weekly lecture

Weekly exercises

Two encoding projects

Literature study/tool evaluation

UE SEQUENCE ANALYSIS AND PHYLOGENETICS

General competences

Objectives

This practical course complements the lecture "Sequence Analysis and Phylogenetics" and aims at practicing the concepts and methods acquired in the lecture.

Subject

Simple sequence comparisons and scoring schemes

Pairwise sequence alignment

Statistical analysis of sequence alignments

Multiple sequence alignment

Methods for computing evolutionary distance

Methods for computing phylogenetic trees

Criteria for evaluation

Marking is based on homework

Methods

Students are given assignments in 1-2 week intervals. Homework must be handed in. Results are to be presented and discussed in the course.

VL SEQUENCE ANALYSIS AND PHYLOGENETICS

General competences

Objectives

Bioinformatics is an interdisciplinary field at the interface of life sciences and computational sciences that deals with the development and application of methods for storing, retrieving, and, in particular, analyzing biological data. The massive data amounts produced by recent and currently emerging high-throughput biotechnologies provide unprecedented potentials, but also pose yet unseen computational challenges – making bioinformatics an essential success factor for the advancement of fields, such as, molecular biology, genetics, medicine, and pharmacology.

This course focuses on basic methods for comparing biological sequences, such as, DNA, RNA, and amino acid sequences. This is complemented by an introduction to the field of phylogenetics, which is concerned with identifying evolutionary relationships among groups of organisms. No prior knowledge in biology is required for this course. Basics of molecular biology are provided up to the minimum that is necessary to understand the ideas behind the bioinformatics tools and algorithms discussed in this lecture.

Subject

Basics of molecular biology

Simple sequence comparisons and scoring schemes

Pairwise sequence alignment

Statistical analysis of sequence alignments

Multiple sequence alignment

Methods for computing evolutionary distance

Methods for computing phylogenetic trees

Criteria for evaluation

Written exam

Methods

Slide presentations complemented by examples presented on the blackboard

VL COMPUTATIONAL GEOMETRY

General competences

Objectives

Basic knowledge of algorithms and data structures for solving geometric problems

Subject

The lecture introduces fundamental problems, algorithms and data structures from the field of Computational Geometry. Among others, the following topics will be covered: Computation of convex hulls, triangulations, range searching, Voronoi diagrams, Delaunay triangulations.

Criteria for evaluation

Exam

Methods

Lecture

PR DIGITAL CIRCUITS LAB

General competences

Objectives

The students can set up and program electronic circuits based on a microcontroller (Arduino).

Subject

Various projects are implemented using a microcontroller board (Arduino) and an electronic component set, for example:

Measurement of resistance values and RC charging curves

Implementation of a component test to identify unknown CMOS logic gates

Realization of a traffic light control

Building an audio generator based on a discrete R-2R DAC

Criteria for evaluation

Assessment of the tasks for preparation, entry test, participation during laboratory exercises, final protocol.

Methods

Practical implementation of laboratory work. If the course is held as a face-to-face event, groups of two are formed. Group work is not intended if the exercises are performed as a virtual lab.

KV ADVANCED COMPILER CONSTRUCTION

General competences

Objectives

Students acquire insights and practice in advanced compilation techniques such as code generation for register machines and register allocation. They understand and can apply the concepts of intermediate program representations and optimization techniques based on them.

Subject

Separate compilation, code generation for register machines (IA32), intermediate program representations (abstract syntax tree, control flow graph, dominator tree, static single assignment form), common compiler optimizations (common subexpression elimination, inlining, loop unrolling, loop-invariant code motion, ...), register allocation. This is a combined course (KV) in which theory is complemented by a programming project, where the students can choose one of several project variants.

Criteria for evaluation

Written exam towards the end of the semester plus an assessment of the programming project, which the students have to present to the lecturer.

Methods

The first part of the semester presents the subject matter based on slides and examples on the blackboard. The rest of the semester is spent on the programming project.

KV ADVANCED INTERACTIVE VISUALIZATION

General competences

Objectives

The aim of this course is to equip students with a practical understanding of data visualization: a multi-disciplinary recipe of science, math, technology, and many other interesting ingredients. The module's emphasis is to instill the critical thinking required to judge best the many analytical, practical, and design decisions involved in this activity. Students will go through the process of designing and implementing a web-based interactive dashboard consisting of multiple visualizations.

Subject

Introduction to tools and libraries that help create tailored interactive visualizations and dashboards. Basic knowledge of web technology (HTML, CSS, JavaScript) is highly recommended.

Criteria for evaluation

The course is project-based. Grading is based on presentations, active participation in discussions, and the delivery of a final report together with the documented source code.

Methods

Interactive tutorials, discussions, and practical assignments.

KV ADVANCED OPERATING SYSTEMS

General competences

Objectives

Students will

build on the background acquired in the lecture "Operating Systems" (official German title "Betriebssysteme") and learn how to apply this abstract knowledge to specific operating systems;

understand modern, practically applied algorithms in current operating systems (in contrast to the significantly simplified versions covered in the lecture "Operating Systems");

and work with a current operating system kernel used in practical deployments.

Practical examples will change over time, but can include e.g. writing hardware drivers for the Linux kernel or other (mostly open source) operating systems.

Students are expected to have mastered the lectures "Operating Systems" and "Systems Programming" before starting this course.

Subject

Operating systems and hardware interaction, drivers, modern scheduling and memory management algorithms in specific operating systems, selected implementation details.

Criteria for evaluation

Practical examples and (oral or written) exam at the end of the lecture.

Methods

Lectures blocks, interactive discussions.

KV APPLICATION ORIENTED KNOWLEDGE PROCESSING

General competences

Objectives

Students know about selected aspects of application-oriented knowledge representation and processing at a more detailed and research oriented level. They have a first insight into ongoing research at the lecturer's research group.

Subject

The topic selection is in accordance to current research activities at the institute for application oriented knowledge processing. The domains are rule-based systems, knowledge representations, access control, trust and software architecture of knowledge based systems.

Criteria for evaluation

Oral exam at the end of the semester and the quality of the project.

Methods

Slide presentations, discussions, a small project (mostly literature research) including a presentation.

KV ASSISTIVE TECHNOLOGIES AND ACCESSIBILITY

General competences

Objectives

Students

develop basic awareness and understanding of the importance assistive technologies and of web and software accessibility

know different disabilities, their implications and requirements for software/system and Human-Comüputer Interface design and development

know important Assistive Technologies (AT) for Human-Computer Interaction

are able to design and implement assistive functionalities and tools for selected groups of people with disabilities

Subject

Potential and importance of ICT/AT for people with disabilities and the ageing population

Disabilities and their impact on usage of software systems

Alternative skills of people with disabilities and how to exploit them for Human-Computer Interaction

Overview to Assistive Technologies (AT), trends and developments

Frameworks for developping assistive functionalities and tools

User centred design of Assistive Technologies; and user involvement

Criteria for evaluation

Participation, contribution, exam and quality of practical examples

Methods

Combination of presentation, discussion and practice

KV BIG DATA ENGINEERING

General competences

Objectives

First of all, the rationale behind the importance of this course's topic is that big data can unfold its full potential only, if its application is made more accessible by explicitly supporting the engineering process of corresponding systems, thereby bridging theory and practice. Thus, in this course, students will learn systematic concepts and techniques for designing and maintaining scalable software systems that are able to gather, store, process and analyze huge volumes of varying data, even at high velocities. In particular, students will not only get in-depth knowledge of the challenges and the current state of the art in this highly active and diverse field of research but also will gain a deep understanding of the often well-established and long-standing engineering theories and techniques like forward- and reverse engineering, design patterns, model-driven development, and schema evolution. Students will get insight into the challenges posed on these techniques by handling huge volumes of data in different formats at high speeds, while maintaining resiliency. Finally, since in this area, most often existing systems and tools are combined to fulfill the peculiarities of big data applications, this course should help students to think about engineering big data in new ways and especially how to select appropriate systems & tools for a certain problem at hand.

Subject

Foundations of Big Data Engineering: Big Data reference architectures, technology classification and selection frameworks, requirements and architecture definition for Big Data applications

Big Data Storage Models: Key-value, Column-Family, Document- and Graph-based, "polyglot" data models

Big Data Processing Models: Events, Batch & Stream Processing, Real-time DBS, Log-based solid data infrastructures, Kafka & the Unix philosophy of distributed data, turning the DBS "inside out"

Engineering of Big Data Schemas: Model-driven techniques for forward engineering (schema-first) & reverse engineering from data & code (schema-on-read), schema-driven consistency checking

Design Patterns for Big Data Schemas: Key-value patterns, Column-Family patterns, Document- and Graph-based, patterns, "polyglot" data model patterns

Evolution of Big Data Schemas: Empirical Analysis of Existing NoSQL Schemas, schema-driven DB evolution, schema transformation, data migration

Criteria for evaluation

Literature studies of students and presentations

Oral Exam

Methods

Introduction to the course topics based on slide presentations

Seminar-style literature studies of students and presentations

VL BIOMETRIC IDENTIFICATION

General competences

Objectives

Students shall be introduced to the diversity of modern biometric identification. They should become acquainted with the various physiological and behavioral traits usable for biometric identification and should understand their processing as well as associated pros and cons.

Subject

Architecure and assessment of biometric identification systems; the whole diversity of modern biometric traits (fingerprint, face, iris, retina, hand geometry, palmprints, DNA, infrared-images, gait, signature, voice); multibiometrics, security of biometric identification systems.

Criteria for evaluation

Written exam at the end of the semester.

Methods

Slide presentation with case studies on the blackboard

KV CLOUD COMPUTING

General competences

Objectives

Students learn how to set up continuous integration/delivery pipelines in a state-of-the art cloud technology, to cover the journey from code to a scalable application running in the cloud.

Subject

This course teaches the basics and underlying principles of the cloud computing paradigm, including history, key terms, challenges and trends. This includes important underlying concepts such as microservice architectures but also specific techniques such as container technologies. In its practical part, the course covers the journey from code to a scalable application running in the cloud. Therefore, students, e.g., learn how to build applications using continuous integration pipelines. State-of-the art cloud technologies to operate applications are explained. Finally, ways to deploy applications are explored, e.g., by setting up a continuous delivery pipeline.

Criteria for evaluation

Students have to present results of a project to be completed as homework (60%). Also, there will be a written exam at the end of the lecture (40%). Both parts have to be completed with a positive mark.

Methods

Mix of presentations and practical work combined with a project as homework.

KV CLOUD SECURITY

General competences

Objectives

Students understand the principles of cloud computing security and architecture. They know the threats and possible security controls at the different layers of abstraction of the cloud.

Subject

Basics and architecture of cloud computing, security issues at the various elements involved when employing cloud services, private & public cloud security, security recommendations for cloud systems, selected basic legal issues of cloud computing, security advantages of the cloud, virtualization security and cryptographic mechanisms

Criteria for evaluation

Grading is based on written assignments and student presentations

Methods

Lecture Presentations, Hands-On Exercises and and student presentations

UE COMPUTER ALGEBRA FOR CONCRETE MATHEMATICS

General competences

Objectives

The students are trained to apply the tools and concepts, introduced in the lecture, in practical problem solving: analysis of algorithms, etc. In particular, the usage of computer algebra software is encouraged.

Subject

See the lecture.

Criteria for evaluation

General criteria: Correctness and clarity of the presented solutions, ability to solve related problems independently; Concrete evaluation: blackboard examples.

Methods

The students have to work out problems and to prepare blackboard presentations (or computer presentations) of the solutions found (using, e.g., computer algebra software). Discussion about the quality and their possible improvements.

KV CONCEPTUAL DATA MODELING

General competences

Objectives

Data modeling is essential to assure high data quality, which is an important prerequisite for industry, data-driven decisions, or artificial intelligence. It is an important skill for data scientists or others involved with data analysis. This course aims at a theoretical and practical basis on data modeling. The process of data modeling is demonstrated by means of real-world case studies and examples. Practical experience is gained by using the methods and applying them in exercises and examples.

Subject

Introduction to data modeling, Data model quality, The Entity-Relationship-Model (ER-Model), Transformation of an ER-Model into a Relational Model, Extensions of the ER-Model, Semantic data models

Conceptual Data Modeling enables students

to obtain a theoretical foundation in conceptual data modeling

to gain knowledge about relevant models and methods and to apply them in real-world projects

to transform a conceptual data model into a specific database schema

to gain practical experiences by applying the methods in exercises and examples

Criteria for evaluation

Exam as well as the submission and evaluation of exercises

Methods

Slide-based presentation, exercises

KV DEBUGGING

General competences

Objectives

Students are familiar with systematic methods of debugging. Based on a solid theory on failures in computer programs, they understand how to find "bugs" in computer programs, how to reproduce them, and how to fix them. They are able to use state-of-the-art debugging tools for modern programming languages and apply this knowledge for (automated) debugging of large scale computer programs.

Subject

Failure and Defects

Testing for Debugging

Analytic Debugging

Symbolic Debugging

Delta Debugging

Fuzzing

Memory Leaks

Profiling and Program Observation

Criteria for evaluation

Written exam and practical exercises in groups of up to three students. The solution of the exercises have to be orally presented.

Methods

Slide presentations, examples on blackboard, tool demonstrations, hands-on exercises.

KV DIGITAL IMAGE PROCESSING

General competences

Objectives

Students understand the principles of processing, analysis, compression and protection of digital images.

Subject

Concept and generation of digital images, discrete transforms for digital images, restoration of images, geometric operations on digital images, digital image enhancement, segmentation of images, feature extraction from images, classification of objects in images, image recognition using convolutional neural networks (CNNs), object detection and segmentation using R-CNNs, semantic segmentation using FCNs, JPEG standards for image compression, digital watermarking.

Project: students have to choose, analyze, and document (in groups) a practical digital image processing system.

Criteria for evaluation

Written exam at the end of the semester; realization, presentation and documentation of (small) practical project.

Methods

Slide presentation with case studies on the blackboard; project

KV ENGINEERING OF AI-INTENSIVE SYSTEMS

General competences

Objectives

The "Engineering of AI-intensive Systems" course combines AI and software engineering. The goal of this course is to understand the challenges, technologies, and best practices for the design and construction of AI-based systems.

Students

understand how the engineering of AI-intensive systems differs from the engineering of a "pure" software system

understand the principles of life cycle of AI systems, their top-down and bottom-up engineering, and the integration of different components

gain practical experiences by working on a challenge problem in a (small) team

gain familiarity with AI techniques associated with software systems such as how to implement ML classifiers for software systems and how to improve their efficiency

Subject

The Engineering of AI-intensive systems course covers the engineering of AI-intensive systems including the engineering life cycle activities (requirements, analysis+design). It also covers a practical example to be worked on as a team.

Criteria for evaluation

Exam and team project; active participation throughout the semester

KV HUMAN/COMPUTER INTERACTION

General competences

Objectives

Students will become familiar with basic principles of human computer interaction. They will understand methods for the design, implementation, and evaluation of interfaces and will be able to apply them.

Subject

Capabilities of Humans and Machines (perception and cognition, knowledge and learning, human information processing, human communication, multimodality, accessibility, input and output devices, WIMP, 3D/virtual, natural/physical/intuitive interaction, affordances) Basic HCI Principles and Models (principles, rules, heuristics, standards, patterns, style guides, multimodal interfaces, predictive and descriptive models, User-Centered Development Process) Designing Interactive Systems (user research and requirements, conceptual models, OO design, activity based design, metaphors, tools and methods for prototyping, describing and specifying interactive systems, design patterns, responsiveness) Implementing Interactive Systems (technologies, standards, guidelines, examples) Evaluating Interactive Systems (user study design, research methods, usability metrics, experimental design, presentation and interpretation of data, statistics, ethical considerations) Advanced Topics (BCI, Mobile HCI, Haptic Feedback, Tangibles, Wearables, Smart Textiles, collaborative interaction, ...)

Criteria for evaluation

Written exam at the end of the semester

Methods

Lecture, discussion, case studies

VL INFORMATION DISPLAYS

General competences

Objectives

This course provides students with technical insights into present and future of display technologies and techniques. Since its invention in the late twenties, television has radically shaped the 20th century. Today, we view most of our visual entertainment and professional day-to-day operations on new and innovative displays. Bulky cathode-ray tubes, for instance, mostly disappeared from our desks. They have been widely replaced by flat panels. The form-factor of home-entertainment displays, as another example, is evolving from small cubes to large planes. The maximal size of flat-panel technology is constrained by technological and applicability issues. If their limits are reached, video projectors have a great potential to continue this trend. Furthermore, small displays are continuously carried around by most of us – as part of mobile phones, personal digital assistants, navigation systems, or laptops. What will come next? What will TVs be like in another 80 years from now? Will pixels die out and turn into voxels or hogels? Will interactive 3D experiences rule out passive 2D ones? These and other questions are of particular interest - especially when considering that it is likely that most of us will yet witness this evolution.

Subject

In particular, this course will discuss the following constitutive topics: Basics of wave optics and geometric optics, fundamentals of light modulation, principles of holography, visual perception and display measures, basic display technologies, projection displays, projector-camera systems and techniques (including calibration and image correction), essence of stereoscopic and auto-stereoscopic displays (including parallax displays, lightfield displays and volumetric displays), functioning of computer generated holography, near-eye displays, real-time computer graphics and computer vision aspects that enable the visualization of graphical 2D and 3D content with such displays, as well as applications.

Criteria for evaluation

< 15 exam registrations - oral exam > 15 exam registrations - eExam (on-site)

Methods

Slide presentation

KV INTRODUCTION TO LINUX

General competences

Objectives

Students are able to...

master the Linux console

understand Linux file systems and find their way around

assess advantages and disadvantages of different distributions

automate repetitive tasks using scripting

adapt Linux systems to special requirements

This course is intended for students without previous experience with Linux operating systems, but who need them during their studies.

Subject

Basic concepts of Linux

Linux console

File hierarchy standard

scripting

Package management

Criteria for evaluation

Continuous evaluation of active participation, regular tests, and multiple home work assignments (non-weekly)

Methods

Presentation and discussion, independent solution of exercises

KV MOBILE COMPUTING

General competences

Objectives

Students will gain technical knowledge and hands-on experience needed to create mobile apps using state-of-the-art mobile technologies, mobile platforms, operating systems, and application frameworks. Furthermore, background knowledge on wireless networks, location awareness, and mobile sensor systems will be obtained.

Subject

The lecture consists of two parts. In the first part, an overview of wireless technologies (such as Wi-Fi, Bluetooth, LTE, and GPS) and different types of mobile applications and development platforms, OSs, and application frameworks are given. In addition, the design of mobile apps is discussed with the aim to give the students a solid background in how to develop compelling sensor-enriched mobile applications. In particular for Android programming, a detailed introduction is provided. The second part of the lecture is a practical part where students apply the techniques and principles to develop a mobile app.

Criteria for evaluation

The course is a project-based course. The project can be done in a group of 1-3 students. Grading is based on the active participation in the theory part, handing in reports and giving presentations, and the final delivery of the project work.

Methods

The course combines a lecture part where interactive participation is ensured by discussions, small exercises, and reports that need to be handed in, and a practical, project-oriented part where students develop a mobile application and present their results.

KV MOBILE WEB DEVELOPMENT

General competences

Objectives

This project-based course aims to provide students with a comprehensive understanding of mobile web development. It will cover the fundamental technologies and frameworks required to design, develop, test, and deploy mobile web applications. Students will learn HTML, CSS, and JavaScript for front-end development, and Python along with Flask and Django for back-end development. SQL for database management, user interface design principles, and best practices for testing and deployment will also be covered.

Subject

What is mobile computing and how it is different from embedded, pervasive, wearable and portable computing? How to classify mobile applications and services? The different types of mobile applications and services development platforms, OS, and application frameworks? How to develop mobile applications using Web technologies (XHTML, CSS, and JavaScript) on the platform of your choice? Using the same standards, techniques, and principles, how to convert a mobile Web application into a native application that run on a specific platform How to recognize and respond to the user location to create compelling location-based services and applications?

Criteria for evaluation

- Assignments: 40% - Final Project: 50% - Participation and Discussions: 10%

Methods

Students will work in teams (of 2-3) to design, develop, test, and deploy a mobile web application. Projects will be presented during the last week of the course.

KV MODEL ENGINEERING FOR DATA-INTENSIVE SYSTEMS

General competences

Objectives

Graduates understand the concepts and techniques of model engineering in general and for data-intensive systems in particular. They are capable of developing data-intensive systems based on model engineering techniques and have knowledge about specific applications and current trends in model engineering.

Subject

Principles of Model Engineering

UML2 – selected topics and modeling heuristics

Metamodeling (MOF, Ecore/EMF)

Model-to-Model Transformations (OCL, ATL as industrial-strength realization of QVT)

Model-to-Code Transformations (XML-based, Java-based, Model-based)

Commonalities and Differences between Model Engineering and Low-Code Development

Model Engineering Specifics for Data-Intensive Systems

Development of Domain-specific Languages (DSL)

Model Engineering Techniques for Forward Engineering (Schema-First) and Reverse Engineering from Data and Code (Schema-on-Read)

Design Patterns and Design Heuristics

Model management (interchange, persistence, comparison, versioning, co-evolution, quality, verification and testing)

Criteria for evaluation

Exam and presentations of students

Methods

Slide-based lecture and student presentations (work in groups)

KV MODELING AND COMPUTER SIMULATION

General competences

Objectives

Getting to know the methods and tools for modeling and computer simulation and its applications

Subject

Differential equation models, numerical integration, discrete event systems, discrete simulation, stochastic simulation and satistical evaluation, hybrid systems, agent-based simulation, application domains, simulation tools

Criteria for evaluation

Student projects, oral exam

Methods

Slide-based lecture, demonstration of applications and tools, student projects

KV MODELING INTERNET APPLICATIONS

General competences

Objectives

The objective of the course is to enable students

to understand the specific characteristics of internet applications and their impact on the development process and modeling methodology.

to understand the role that modeling plays in the development of internet applications.

to understand the strengths and weaknesses and thus the applicability of modeling approaches with respect to various internet application types.

to be familiar with various web access structures and thus be able to apply them appropriately.

to develop internet applications by means of a state-of-the-art model-driven approach.

Subject

Characteristics of internet applications; role of modeling in web engineering; basic model-driven engineering for internet applications; overview on specific approaches (WebML, OOWS, OO-H, UWE, etc.); model-driven development of internet applications with WebML and WebRatio.

Criteria for evaluation

Grades will be based on the results of an individual smaller exercise project, a larger project conducted in groups and an oral presentation thereof.

Methods

Slide presentation with case studies; guided workshop, individual exercise with tutoring, group-wise project work

UE PROBABILISTIC MODELS

General competences

Objectives

To provide an opportunity for students to experiment with probabilistic models and reasoning methods, in order to better understand the workings and limitations of these methods. This class is highly recommended as a supplementary course to the VO "Probabilistic Models", where the theoretical foundations are explained.

Subject

Practical experiments with probabilistic models. Development of simple systems that model and reason about some given problem. Specific focus: (discrete) Bayes Nets and temporal models (Hidden Markov Models, Kalman Filter).

Criteria for evaluation

Independent experimentation based on given problem specifications. Written and/or oral report on the results.

KV PRODUCT LINE ENGINEERING

General competences

Objectives

Students...

know how to use product line engineering methods and tools

understand domain engineering and application engineering processes

can develop variability models and implement variable software

know industrial case studies

Subject

Product Line Engineering Processes

Product Line Scoping and Variability Elicitation

Feature Modeling

Decision Modeling

Variability Mechanisms/Implementation

Modular Architectures

Product Line Engineering Tools

Product Derivation and Configuration

Product Line Testing and Analysis

Product Line Evolution

Criteria for evaluation

Final exam at the end of the semester

2-4 (Group) Exercises

Participation

Methods

Presentations with slides and tool demos

Invited Talks (from Industry and/or Academia)

Discussion of new and submitted exercises

Discussions

Student presentations (of exercise results)

VL QUANTUM COMPUTING

General competences

Objectives

We will convey the fundamental possibilities and limitations of modern quantum computing. This includes basic knowledge of the underlying principles and their implications. Students will also learn how to read and work with quantum circuits -- the most prevalent model of quantum computing. This also sets the stage for discussing far-term applications of fully functional quantum computers. In contrast to many standard quantum computing lectures, we will also put an emphasis on near-term use cases of imperfect quantum architectures. Finally, the students will learn that quantum potential is not limitless. Similar to conventional computers, quantum architectures are subject to complexity-theoretic bottlenecks.

Subject Topics include:

Reversible logic & circuits

Quantum circuits & quantum computing

Fundamental implications and challenges

Far-term quantum algorithms

Near-term quantum algorithms

Quantum complexity theory

Criteria for evaluation

Scribing duties, oral exam and/or a small project

KV SAT SOLVING

General competences

Objectives

The students are proficient in recent SAT solving algorithms.

Subject

Encoding: NNF, Tseitin, AIGs, cardinality constraints encoding, bit-blasting.

Preprocessing: DP, BVE, BVA, blocked clauses, autarkies, Stalmarck, recursive learning, clause redundancy, probing.

Solving: DPLL, CDCL, learning, implication graph, failed literals, UIP, clause minimization, restarts, clause reduction.

Criteria for evaluation

Oral exam, student projects.

Methods

Slide-based lecture, tool demos, small practical projects.

KV SEMANTIC DATA MODELING AND APPLICATIONS

General competences

Objectives

The development of complex information systems in a heterogeneous application context requires modeling methods for data as well as information objects including their semantics. The objective of this course is to teach the application of object-oriented data and information models for the development of information systems. Especially in heterogeneous application scenarios, the consideration of the semantics is of special importance. Ontologies are presented as formal, explicit specifications of a shared conceptualization and different ontology engineering processes and methodologies are discussed. Practical experience is gained by using the methods and applying them in exercises and examples.

Subject

Information systems development, Object-oriented data models (UML), Ontologies, Ontology engineering, RDF, OWL, Modeling tools

Semantic Data Modeling and Applications enables students

to gain knowledge about object-oriented data models

to apply specific UML models for data modeling and information system development

to develop ontologies and knowledge graphs

to gain practical experiences by applying the methods in exercises and examples

Criteria for evaluation

Exam as well as the submission and evaluation of exercises

Methods

Slide-based presentation, exercises

KV STATISTICS 2

General competences

Objectives

Students understand advanced methods of inductive statistics with focus on parametric and non-parametric statistical test procedures. They can analyze data using these methods and can interpret statistical methods and results in other work. They can also perform these statistical analyzes using the program package R.

Subject

parametric statistical tests for continuous data (one-sample t-test, two-sample-test, paired t-test)

Sample size estimation and power analysis for the t-test family

non-parametric statistical tests for continuous and/or rank data (Kolmogorov-Smirnov test, Mann-Whitney-U test, Wilcoxon test)

tests for categorical data (binomial test, chi-square test, Fisher's exact test, McNemar's test)

summarizing the results of a binary classification system (sensitivity, specificity, ROC curves, ...)

odds ratio and risk ratio (interpretation/tests)

summary statistics for association/correlation (Cramer's V, correlation coefficient, partial correlation coefficient) and corresponding statistical tests

introduction into analysis of variance

introduction into R

Criteria for evaluation

short weekly homework assignments

exam at the end of semester

each part is weighted with 50% regarding the final grade

Methods

lecture by instructor

weekly homework assignments and presentation/discussion of these assignments

live coding in R

KV WEB ENGINEERING

General competences

Objectives

Students know Web engineering concepts, technologies and tools and are able to apply them for the realization of web applications.

Subject

Web engineering & web application characteristics

web engineering process and tasks

web architectures and technologies,

selected topics of web engineering: modeling, usability/accessibility, performance/caching, personalization of web applications, web 2.0 & web science

Criteria for evaluation

exercises, exam, in-class contribution

Methods

presentation, exercises (group work)

KV WEB PERFORMANCE

General competences

Objectives

The course focuses on understanding methods and mastering tools to analyze computer and network system performance.

Subject

Basic concepts regarding performance key data and models. Methods in performance evaluation (modeling and measuring). Analysis tools. Case studies.

Criteria for evaluation

attendance and participation, mini project

Methods

lecture, case studies, homework

KV WEB SEARCH AND MINING

General competences

Objectives

Students have competence in fundamentals and technologies of (1) Web Search and their application in search engines (2) Web Mining including web scraping and social media mining and (3) Question Answering and Chatbots . They are able to implement and evaluate applications in these fields and have knowledge about related fields and current research topics

Subject

1) Web Search

information retrieval “in a nutshell”

web search challenges

search engines: Google, Quant et al.

web crawling

weighting and ranking: PageRank etc.

search engines evaluation

site search

search engine optimization (SEO)

search engine user interfaces

social media search

deep web search

spam and defacement detection

tools and applications

2) Web Mining

information extraction “in a nutshell”

web information extraction challenges

web scraping

crowd/knowledge-based extraction

social media mining (twitter, blogs etc.), opinion mining, sentiment analysis

tools and applications

3) Question Answering & Chatbots

approaches and architectures

tools and applications

Criteria for evaluation

exercises, exam, in-class contribution

Methods

slide presentation (slides on Moodle), exercises (group work)

KV WEB SECURITY

General competences

Objectives

Students know about attack vectors, defense and recognition opportunities and strategies to prevent security issues from arising. They can test web-based applications for vulnerabilities.

Subject

Types of attacks (such as SQL injections, cross-site scripting, cross-site request forgery, session stealing/fixation), counter measures (including input validation, nonces, indirections). Examples of attacks and their recognition. Discovering and adjusting security relevant programming mistakes and countermeasures in drafting and implementation.

Criteria for evaluation

Written exam

Methods

Lecture and discussion

KV WEB USABILITY

General competences

Objectives

Students understand the importance of usability as part of web design. They know the interdisciplinary process and work-flow of usability engineering and the most important usability methods and tools. They develop skills in efficiently applying them in web (re)design projects. They are able to evaluate and measure web pages in terms of usability and are able to develop ideas, concepts and plans for re-design.

Subject

Definition of term and domain usability

Related disciplines and interdisciplinary approaches

The Usability Engineering Process

Guidelines, methods and tools in usability engineering

Basic concepts and importance of HCI

Contributions of Cognitive Psychology

Web Accessibility

Examples and applications

Criteria for evaluation presence

Contributions

Exam

Quality of practical work

Methods Presentation

Further reading

Discussion

Evaluation and test of Web Pages

(Re)Design of web pages in practice

KV VLSI DESIGN

General competences

Objectives

The students master the design of digital circuits using VHDL and have an overview of the design flow from VHDL to the physical implementation in an integrated circuit.

Subject

The lab exercises consist of:

Introduction to the basics of the design and synthesis of a 16-bit RISC processor core as a full custom IC, based on existing VHDL knowledge.

Simulation of the entire system, including timing data.

Getting to know a synthesis library and the synthesis tool DesignVision, and the physical implementation in Cadence Innovus.

Criteria for evaluation

Grading of the project, test at the end of the semester (oral or written).

Methods

Introduction to the topic using a slide presentation, homework, and laboratory appointment to complete the project. Group work is not planned.

UE COMPUTATIONAL GEOMETRY

General competences

Objectives

Supports to achieve the goals of the accelerated course

Subject

see content of the accelerated course

Criteria for evaluation

"Kreuzerlübung" and presentation at blackboard

UE COMPUTER ALGEBRA

General competences

Objectives

practical experience with concepts and algorithms in computer algebra

Subject

weekly exercises and projects

VL COMPUTER ALGEBRA

General competences

Objectives

In the last decades big parts of mathematics have been algorithmized and many mathematical problems (or problems coming from natural and technical sciences that can be modeled in mathematics) can be solved with the computer. A major contribution to this algorithmic revolution is computer algebra. This lecture aims at introducing the most crucial algorithms in this field and illustrating how they can be used for non-trivial applications.

Subject

We discuss constructive symbolic methods for simplification of expressions and solving algebraic (ie, polynomial) systems of equations. Among others, the following algorithms are explored:

basic structures and algorithms

the extended Euclidean algorithm, polynomial remainder sequences and applications

modular methods based on Hensel lifting and the Chinese Reemainder Theorem (resultants, gcd, factorization)

a gentle introduction to Gröbner bases

symbolic summation and integration

Criteria for evaluation

Depending on the needs of the participants there will be a written or oral exam.

Methods

The different algorithms will be presented on the blackboard. Concrete examples will be carried out with the computer.

SE SEMINAR IN COMPUTATIONAL ENGINEERING

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in Computational Engineering

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

SE SEMINAR IN DATA SCIENCE

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in Data Science

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

SE SEMINAR IN INTELLIGENT INFORMATION SYSTEMS

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in Intelligent Information Systems

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

SE SEMINAR IN NETWORKS AND SECURITY

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in Networks and Security

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

SE SEMINAR IN PERVASIVE COMPUTING

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in Pervasive Computing

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

SE SEMINAR IN SOFTWARE ENGINEERING

General competences

Objectives

Seminars guide students to do scientific work. In particular, they learn

to work independently on a scientific topic in the area of Software Engineering

to do literature research

to write a seminar report according to scientific standards

to give a presentation and to defend it

to discuss the presentations of other participants

Subject

Topics depend on the subtitle of the seminar. Students have to select a subtopic of the seminar and work on it independently. They have to do literature research, write a seminar report and give a presentation.

Criteria for evaluation

Seminars are marked by assessing the seminar report, the presentation, and the participation in discussions.

Methods

Independent literature research; submission of a written seminar report; presentation of the chosen seminar topic in a talk to other students.

PR PROJECT PRACTICAL

General competences

Objectives

Students should demonstrate the ability to practically and methodically apply the knowledge learned in their studies, to relate their work to the state-of-the-art literature and to document the results. As part of the practical, an independent thesis has to be written.

Subject

The bachelor's thesis is a written documentation of a practically oriented Computer Science project. Its formal structure should follow the form of a scientific publication.

Criteria for evaluation

Evaluation criteria are the correctness, elegance and maturity of the solution as well as the clarity of the written thesis.

Methods

Independent literature survey; Solution of a practical problem using Computer Science methods; Written presentation of the solution in a bachelor's thesis.