THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF VISUAL COMPUTING

Intended learning outcomes

Students know the mathematical-theoretical foundations of visual computing and are able to apply them in the form of methods for computer graphics, visualization, image processing, and computer vision.

Contents

This course covers the following topics:

Basics of affine and projective geometry, along with their use in computer graphics, especially in the rendering pipeline.

Differential calculus in 2Dand 3D, with applications in image processing and visualization.

Integral calculus in 2Dand 3D, with applications in visualization and rendering.

Ordinary differential equations, with examples from computer animation and flow visualization.

Partial differential equations for image processing.

Interpolation and approximation for geometry processing, visualization, and image processing.

Fourier analysis, Fourier transform, sampling theorem, and filtering, with examples from imaging.

Wavelet analysis applied to image processing.

Empirical research methods for visual computing.

Statistical analysis for scientific experiments.

Exercises deepen the understanding of the mathematical and theoretical foundations. Furthermore, they complement the lecture with hands-on partical applications and implementations. Practical exercises are partially with OpenGL, Matlab, and R.

ADVANCED SEMINAR COMPUTER SCIENCE

Intended learning outcomes

The students learn how to work with scientific literature for getting acquainted with a certain subject. They are able to extract the central statements from such publications, to collect and interpret additional data and to present their results to an audience.

Contents

reading scientific literature &; present the contents to an audience

teaching and learning method

COMPUTER VISION

Description of study/examination achievements

[29431] Computer Vision (PL), written or oral, 90 min., weight: 1.0

Prerequisite: Practice certificate, criteria will be announced in the first lecture

[Prerequisite] Prerequisite (USL-V), written, possibly oral

Description

(Recommended) Requirements

Module 10190 Mathematics for Computer Scientists and Software Engineers

Module 10170 Imaging Science

Intended learning outcomes

The student has mastered the basics of feature extraction and representation, 3D machine vision, image segmentation and pattern recognition. He/she can classify problems from the field and solve them independently using the algorithms and methods learned.

Contents

Linear Diffusion, Scale Spaces

image pyramids, edges and corner detection

Hough transformation, invariants

texture analysis

Scale Invariant Feature Transform (SIFT)

Image sequence analysis: local methods

motion models, object tracking, feature matching

Image sequence analysis: global methods

Camera geometry, epipolar geometry

Stereo Matching and 3-D Reconstruction

shape-from-shading

Isotropic and anisotropic nonlinear diffusion

Segmentation with global methods

Continuous morphology, shock filter

Mean Curvature Motion

Self-Snakes, Active Contours

Bayesian decision theory of pattern recognition

Classification with parametric methods, density estimation

Classification with non-parametric methods

dimensionality reduction

teaching and learning method

PRACTICAL COURSE VISUAL COMPUTING

Intended learning outcomes

During this practical course, students will learn about approaches to rendering and visual computing technologies and will know how to implement these. They will learn about polygon based approaches as well as volume rendering approaches. The students will learn how to proceed a small project on their own (independently).

Contents

OpenGL

Qt framework

ray tracing

Volume Rendering

Independent Project

SCIENTIFIC VISUALIZATION

Intended learning outcomes

Student gains expertise about fundamental concepts and techniques of scientific visualization. This includes algorithms and mathematical background, data structures and implementation aspects as well as practical experience with widely available visualization tools.

Contents

Visualization discusses all aspects of visual representations of data gained from experiments, simulations, medical scanning machines, data bases an the like. The aim of visualization is to gain further insights into the data or the generate simple representations of complex phenomena or issues. For that, known techniques from the research area of interactive computer graphics as well as novel techniques are applied.

The following topics will be discussed:

Introduction, history, visualization pipeline

Data acquisition and representation (sampling, reconstruction, grids, data structures)

PerceptionBasic concepts of visual mappings

Visualization of scalar fields (extraction of iso-surfaces, volume rendering)

Visualization of vector fields (particle tracking, texture-based methods, topology)

Tensor fields, multivariate data

High-dimensional data and information visualization

INFORMATION VISUALIZATION AND VISUAL ANALYTICS

Description of study/examination achievements

Successful participation in the exercise.

Description

(Recommended) Requirements

Basics of Programming

Intended learning outcomes

Students will gain knowledge of fundamental concepts and techniques of information visualization and visual analytics, including algorithms and mathematical background, data structures and implementation aspects, as well as practical experience with visualization tools.

Contents

Topics covered in this course:

- Perception and Cognition

- Graphics and Networks

- Hierarchies and trees

- Multi- and high-dimensional data visualization

- time series visualization

- Visual Analytics

- Geographical visualization

CORRESPONDENCE PROBLEMS IN COMPUTER VISION

Description of study/examination achievements

[55641] Correspondence Problems in Computer Vision (PL), written, possibly oral, 90 min., weight: 1.0, pre-examination requirement: practice certificate, criteria will be announced in the first lecture [pre-examination requirement] Pre-examination requirement (USL-V), written, possibly oral

Description

(Recommended) Requirements

Module 10190 Mathematics for Computer Scientists and Software Engineers

Module 10170 Imaging Science

Module 29430 Computer Vision

Intended learning outcomes

The student can independently classify correspondence problems in the computer vision area, mathematically model solution strategies and then implement them appropriately algorithmically.

Contents

Basic methods: block matching, occlusion detection, feature finding, feature matching

Optical flow: local and global differential methods, parameterization models, assumption of constancy, data and smoothness terms, numerics, large displacements, high-precision methods

Stereo reconstruction: Projective geometry, epipolar geometry, estimation of the fundamental matrix

Scene Flow: Joint Estimation of Structure, Motion and Geometry

Medical Image Registration: Mutual Information, Elastic and Curvature-Based Regularization, Landmarks

Particle Image Velocimetry: Div-Curl Regularization, Incompressible Navier Stokes Prior

VIRTUAL AND AUGMENTED REALITY

Description of study/examination achievements

Examination (PL), written or oral, 90 min, weighting: 1,

USL-V: successful exercise participation

Description

(Recommended) Requirements

Basic concepts of Human Computer Interaction

Basic concepts of computer graphics

Intended learning outcomes

After the course students understand and can apply different Virtual and Augmented Reality techniques and methods

Students can build basic VR/AR applications using Unity

Contents

Topics covered in this course:

Architecture of VR/AR systems

Hardware and software techniques for VR/AR

Geometry and rendering

Input devices, navigation, and interaction

Sound in VR/AR

Immersive Analytics

Evaluation of VR/AR systems

PRACTICAL COURSE INFORMATION VISUALIZATION

Description of study/examination achievements

Course-Accompanying Examination (LBP): Programming Projects

Description

(Recommended) Requirements

Information Visualization and Visual Analytics

Intended learning outcomes

During this practical course, students will learn about technologies for developing interactive information visualizations and practical aspects of programming these. The course will start with data wrangling (cleaning data, finding and mending gaps in the data), transforming and filtering the data to visualizes, mapping to appropriate visual structures, as well as creating interactive information visualizations. Students will apply these steps during several small exercises creating interactive information visualizations. Last, students will apply their learned knowledge by developing an independent interactive information visualization of a dataset chosen on their own.

Contents

• D3.js • Data Wrangling • Interactive Information Visualization (Eg, Graphs & Networks, Trees & Hierarchies, Multidimensional Data Visualizations, Temporal and Spatial Data Visualization) • Independent Programming Projects

ACQUISITION AND ANALYSIS OF EYE-TRACKING DATA

Description of study/examination achievements

Examination (PL): Data acquisition, analysis and documentation of one of several specified eye-tracking experiments. To be submitted as a written paper at the end of the semester

Description

(Recommended) Requirements

Basic programming skills (Python, R, Matlab or Julia)

Intended learning outcomes

The goal of this course is to put participants in the position to plan and conduct their own eye-tracking experiments. Our aim will be to understand each step in the acquisition, preprocessing, analysis pipeline up to the statistical analysis. Time permitting we will also look into some prominent computational models of eye movement behavior.

Contents

Eye physiology, visual perception, oculo-motor control and types of eye movements, eye-tracking technologies, design and implementation of eye-tracking experiments, acquisition of eye movement data, quality control, algorithms for the detection of eye movements and gaze fixations, conventional eye-tracking measures, scanpath analysis, computational models of eye movement behavior.

MACHINE PERCEPTION AND LEARNING

Description of study/examination achievements

Graded course performance (BSL): Participation and successful completion of the course project
Examination performance (PL): Written exam (90 minutes) on the lecture “Machine Vision and Learning”

Description

(Recommended) Requirements

Machine learning, computer vision, deep learning for speech and language processing, reinforcement learning

Intended learning outcomes

The core competency acquired through this course is a solid foundation in deep learning algorithms to process, model, and interpret human input into computing systems. In particular, after finishing this course, students should be able to develop systems that can deal with the problem of detecting humans and human body parts in still images or image sequences as well as encoding their movement, answering questions and engaging in a dialogue about visual input in natural language, interactive and reinforced learning and collaboration with human agents, bridging between data-driven and symbolic visual representations, generating visual representations, explaining their decisions and respecting ethical principles, also using multi-modal data, among others

Contents

Students will learn about fundamental aspects of modern machine learning methods for perception. Students will learn to implement, train, and evaluate their own neural networks and gain a detailed understanding of cutting-edge research in learning-based computer vision and HCI. Topics covered in the course include convolutional and recurrent neural net-works, Transformers, multimodal and interactive machine learning, gene-erative models, explainable and neuro-symbolic AI, (deep) reinforcement learning, and graph neural networks. Theory-focused lectures will be complemented with interactive tutorials in which students will gain hands-on experience with neural network fundamentals, as well as with rhyme-implementation tasks in which students will learn to understand, reimplement, and reproduce selected research papers published at top computer vision and machine learning venues. A course project spanning the second half of the course will involve developing, implementing, and training a complex neural network architecture and applying it on a real-world dataset. Projects will be proposed by members of the Perceptual User Interfaces group and closely linked to their ongoing research.

MACHINE LEARNING

Intended learning outcomes

Students will acquire an in-depth understanding of Machine Learning methods. The concepts and formalisms of Machine Learning are understood as generic approaches to a variety of disciplines, including image processing, robotics, computational linguistics and software engineering. This course will enable students to formalize problems from such disciplines in terms of probabilistic models and the derive respective learning and inference algorithms.

Contents

Exploiting large-scale data is a central challenge of our time. Machine Learning is the core discipline to address this challenge, aiming to extract useful models and structures from data. Studying Machine Learning is motivated in multiple ways: 1) as the basis of commercial data mining (Google, Amazon, Picasa, etc), 2) a core methodological tool for data analysis in all sciences (vision, linguistics, software engineering, but also biology, physics, neuroscience, etc) and finally, 3) as a core foundation of autonomous intelligent systems (which is my personal motivation for research in Machine Learning).

This lecture introduces modern methods in Machine Learning, including discriminative as well as probabilistic generative models. A preliminary outline of topics is:

motivation

regression: linear regression, kernel methods

classification: kNN, Naive Bayes, logistic regression, decision trees, support vector machines

ensemble methods: bagging and boosting

neural networks: mixture distributions, backpropagation, CNNs, RNNs

clustering: K-Means, EM, agglomerative clustering, PLSA

dimensionality reduction

Cross-cutting topics: evaluation, loss functions, regularization, gradient descent

REINFORCEMENT LEARNING

Description of study/examination achievements

Prerequisites for examination: Practice certificate, criteria will be announced in the first lecture

Description

(Recommended) Requirements

Solid knowledge in linear algebra, probability theory and optimization. Rough knowledge of artificial intelligence. Fluency in at least one programming language

Intended learning outcomes

Students will acquire a deep understanding of Reinforcement Learning methods. Reinforcement Learning addresses the problem of learning optimal behavior (strongly related to optimal control) from data. This course will enable students to apply Reinforcement Lea algorithms in simulated domains and real robotic systems.

Contents

Reinforcement Learning considers how an agent, interacting with a world, can improve or learn optimal behavior based on own experience or teacher demonstration. This branch of Artificial Intelligence and Machine Learning has become increasingly important foundation of robust intelligent systems and robotics. Optimal exploration (behavior that optimizes the agent's information gain) is a particularly interesting aspect of reinforcement learning. This lecture will introduce to the theory of Reinforcement Learning and then discuss state-of-the-art algorithms in this area. A focus of the lecture will be on deep reinforcement learning.

Markov Decision Processes and Bellman's optimality principle

basic model-free RL methods (policy gradient, Q-learning, etc)

model-based RL methods

offline reinforcement learning

relational RL

inverse RL, learning from demonstration and instruction

basics of reinforcement learning theory

transfer and multi-task learning

applications

THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF SERVICE TECHNOLOGY AND ENGINEERING

Description of study/examination achievements

written exam (PL), 120 min, weight: 1

Description

(Recommended) Requirements

Basic knowledge on algorithms and data structures

Intended learning outcomes

The participants get to know the basic techniques in discrete optimization and have a good overview of the standard methods to be able to deal with new problems instances.

Contents

We teach basic techniques of discrete optimization like (integer) linear programming, approximation algorithms and network flow algorithms.

LABORATORY COURSE HIGH PERFORMANCE PROGRAMMING WITH GRAPHICS CARDS

Intended learning outcomes

Understanding of the Architecture and Programming Model of Graphics Cards

Contents

Architectures of Graphics Processing Units (GPUs)

Treads

Kernel Calls

Memory Architecture

Data Transfer between GPUs and CPUs

Number formats

Benchmarking

Deviations between CPU and GPU Programs

teaching and learning method

Course takes place in the Lab

SIGNAL PROCESSING AND ANALYSIS OF HUMAN BRAIN POTENTIALS (EEG)

Description of study/examination achievements

Course-accompanying examination (LBP): Documentation and analysis pipeline of one of several given EEGs

Description

(Recommended) Requirements

Python programming skills

Basic knowledge of linear algebra

Intended learning outcomes

Overall goal: Plan and implement an analysis pipeline for EEG data - Explain which neuroimaging technique is useful when (M/EEG/fMRI/eye-tracking/reaction-time) to answer a question on the brain - Understand and use filtering in time and space and diagnose filter-problems.

Perform EEG data cleaning

Understand and apply blind source separation

Build, apply and interpret forward encoding models

Select, apply and interpret statistics

Understand when, and how to use decoding and which algorithms to use

Calculation and limitations of source space

Interpretation of EEG results

Contents

In this course we will have a look at typical EEG processing and analysis steps. We will move from basic processing to state-of-the-art analysis techniques. A focus is set on intuition of methods and practical use of the techniques. At the end of the course you will be able to setup your own analysis pipeline and understand many important concepts the analysis of human EEG data (see Learning Goals for more details). The lecture will dive into the conceptual and mathematical foundations of state-of-the-art EEG analyses. The homeworks will get you started to directly implement the algorithms and will introduce you to MNE-python, a powerful analysis library. The lectures will be asynchronous with mandatory self-assessment (ungraded). The exercises will be asynchronous with mandatory homeworks (pass/fail) The grade will be determined by a semester-project where you will be analyzing a dataset starting from raw data. You will be able to select data from several experiments and several “analysis-modules” eg statistical ERP analysis, decoding, time-frequency analysis or source level analysis.

INTERNSHIP IN INTERACTIVE SYSTEMS

Intended learning outcomes

Students learn how to develop interactive systems. They understand the development process and can develop interactive systems for specific platforms.

AUTOMOTIVE AND ASSISTIVE COMPUTER VISION

Description of study/examination achievements

- Examination (PL) Automotive and Assistive Computer Vision, written or oral, 60 min., weight 0.5.

- Graded course performance (BSL): Participation and successful completion/presentation of the course project (criteria will be announced in the first lecture), weight 0.5.

Description

(Recommended) Requirements

Basic knowledge of pattern recognition, deep learning, and computer vision, acquired for example through prior attendance of the modules Computer Vision, Deep Learning, Machine Learning, Machine Perception and Learning, is recommended. For the completion of the project, programming skills in Python are required. Initial experience with the PyTorch framework is a advised but can also be acquired during the course

Intended learning outcomes

This course provides students with a comprehensive understanding of deep learning-based visual recognition problems and methods specifically relevant for dynamic real-world applications in automotive and assistive technology. Students understand the various tasks of computer vision relevant for these domains and are able to apply deep learning methods for specific challenges encountered in these fields, such as uncertainty, robustness against distributional shifts, limited training data and computational resources, recognition under adverse conditions, multi-sensor fusion, etc.

Contents

Computer vision is a vital technology in both automotive innovations like autonomous driving and in developing assistive technologies such as assistive robotics or tools for guiding the visually impaired. Despite rapid progress linked to the rise of deep learning, CV faces significant challenges in real-world applications, including handling adverse conditions, reliance on large annotated datasets, computational demands, under-standing decision-making processes and uncertainty quantification. This module explores the fundamentals and advanced developments in CV, addressing these challenges with a focus on applications in dynam-ic environments. By examining both automotive and assistive technologies, students will learn about the synergies and shared obstacles between these fields. The curriculum covers essential CV techniques, efficient architectures, and domain adaptation, complemented by hands-on projects to apply what they've learned in practical settings. Among others, the following topics will be covered:

- Fundamental methods and tasks: overview of the relevant building blocks and optimization techniques (eg, CNNs, visu-al transformer models), tasks relevant for intelligent cars, eg, obstacle detection and scene understanding, perception in-side and outside the vehicle; and assistive technologies (CV for improved mobility, activity recognition, document analysis)

- Uncertainty in computer vision, open set recognition, visual recognition with limited training data

- Domain adaptation/generalization and robustness against dis-tributional shifts

- Sensor fusion

- Efficient architectures

- Discussion of SoA architectures and synergies between au-tomotive and assistive technologies, long-term implications.

Alongside the lectures, student projects are an integral part of this lecture. These projects focus on analyzing and presenting recent research papers as well as implementing/using them for a specific use-case or application to gain hands-on experience. The students will present their results and write a report summarizing their learnings from the project.

DATABASES AND INFORMATION SYSTEMS

Description of study/examination achievements

Preliminary examination requirements: modalities will be specified in the first lecture

Description

(Recommended) Requirements

Knowledge of the basics of databases and information systems, for example from the lecture "Modelling", is assumed.

Intended learning outcomes

The students know concepts and algorithms for implementing basic components of database systems. This knowledge is required both for the use and administration of database systems and for the implementation of database-based applications.

Contents

The lecture "Databases and Information Systems" is designed as an introductory event in the advanced area of database systems. Building on the content of the lecture "Modeling", the design and implementation aspects of database systems are considered in particular. The development, installation and administration of database systems determine both the choice of material and the level of detail. As a basis for all further considerations, a layered model for describing a general database system is presented. Building on this, the individual system layers are discussed in detail, the components to be implemented there are considered and the prevailing algorithms are described and evaluated. The following aspects are examined in more detail:

application programming interface

external storage management

DBS buffer management

storage structures and access path structures

request processing and request optimization

transaction processing, synchronization

logging and recovery.

DATA COMPRESSION

Description of study/examination achievements

[29581] Data Compression (PL), written exam, 90 min., weight: 1.0 , written 90 min. or oral 30 min.

Description

(Recommended) Requirements

This course requires basic knowledge in mathematics.

Intended learning outcomes

The students learn the concepts of data compression and acquire an understanding of different algorithms for data compression. Furthermore they will be able to implement and further develop the algorithms discussed in the course.

Contents

Shannon Entropy

Huffman coding

Universal codes

Arithmetic coding

Lossy and lossless compression

Image data compression

Dictionary based compression

DIGITAL SYSTEMS

Description of study/examination achievements

[29591] Digital Systems (PL), written or oral, 90 min., weight: 1.0, written examination of 120 min. or oral examination of 30 min. [Preliminary examination] Preliminary examination (USL-V), written, possibly oral

Description

(Recommended) Requirements

Knowledge of a subject from computer engineering or a similar field.

Intended learning outcomes

The students master the design of digital systems through the integration of digital components on a board and the realization of digital components using FPGAs.

Contents

Practical introduction to system design with digital components such as interface modules for communication, FPGAs, processors, intelligent sensors, etc.

Introduction and use of the hardware description language VHDL for the design of digital systems

Digital Systems and Board Integration of Digital Components

Construction of computer boards and Gbit/s interconnects

Design at higher levels of abstraction for rapid development of prototypes

EMBEDDED SYSTEMS ENGINEERING

Description of study/examination achievements

[29711] Embedded Systems Engineering (exam) (PL), written, possibly oral, 120 min., weight: 1.0

Description

(Recommended) Requirements

no

Intended learning outcomes

Master-level understanding of the design methodology and advanced design techniques for constructing and analyzing embedded hardware / software systems.

Contents

1. Introduction to embedded systems and their design constraints 2. Synthesis models and algorithms 3. System level synthesis 4. High level synthesis 5. Pipelined data path and controller design 6. Software task scheduling and schedulability analysis 7. Static and dynamic methods for scheduling and priority assignment 8. Communication architectures for embedded systems

MOBILE COMPUTING

Description of study/examination achievements

Examination duration: 90 minutes written or 30 minutes oral

Description

(Recommended) Requirements

computer networks

Intended learning outcomes

The knowledge that has been acquired in the course Computer Networks regarding concepts, protocols, and technologies of computer networks will be extended to mobile and wireless communication systems and procedures. The objective of this lecture is to understand problems that might occur in the usage of mobile devices, mobile systems, and mobile communication as well as to obtain knowledge to develop solutions to these problems, and communicate with experts. The participants will learn about advantages and disadvantages of specific mobile and wireless communication technologies and protocols, and will be able to use these technologies and protocols for developing mobile applications and modify them as needed. The exercises are used to provide practical experience in the programming, analysis, and performance evaluation of mobile and wireless systems as well as the expertise in the usage of appropriate tools.

Contents

Fundamentals of wireless data transmission

Media access for wireless networks

Location Management

Wireless wide-area networks and mobile communication systems (GSM, GPRS, UMTS)

Wireless local area and personal area networks: IEEE 802.11, Bluetooth

Ad hoc Networks: routing protocols and algorithms

Mobility in IP networks: Mobile IP

Transport layer protocols for mobile systems

Mobile data management concepts

Android programming

MODELING, SIMULATION, AND SPECIFICATION

Intended learning outcomes

Master-level understanding of fundamental models of computation and their simulation, ability to apply them to embedded systems specification.

Contents

Given the complexity and implementation cost of contemporary electronic systems, it is essential to specify their intended functionality before elaborating the implementation. This course focuses on the model-based and executable specification of embedded systems and covers the following topics:

Hierarchical concurrent state machine models,

Kahn process networks, synchronous data flow networks,

specification of timing, concurrency, and non-functional aspects,

object-oriented modeling of embedded systems,

event-driven simulation with the example of the SystemC library,

modeling levels with emphasis on transaction level modeling.

teaching and learning method

Attendance time: 42 hours

Self-study: 138 hours

Total: 180 hours

HARDWARE-SOFTWARE CODESIGN

Description of study/examination achievements

[42921] Hardware-Software Codesign (PL), written or oral, 120 min., weight: 1.0

Description

(Recommended) Requirements

Bachelor's course "Fundamentals of Embedded Systems" or equivalent knowledge

Intended learning outcomes

Ability to conceptualize systems so that an application-specific, optimized trade-off between hardware and software implementation of system functionality is achieved.

Contents

This module deals with the joint design and optimization of hardware and software for pre-defined applications, covering the following topics: 1. Models for system specification 2. Modeling and simulation with the SystemC library 3. Synthesis of system architectures 4. Resource allocation and operation binding 5. Partitioning of functionality among hardware and software 6. Scheduling and schedulability for parallel multi-core architectures 7. Methods for system optimization 8. Application specific instruction set processors (ASIPs) 9. Network-on-Chip (NoC) interconnect architectures

INTERNSHIP IN DISTRIBUTED SYSTEMS

Description of study/examination achievements

[45751] Distributed Systems Internship (PL), Other, Weight: 1.0

Description

(Recommended) Requirements

- Distributed Systems - Computer Networks II

Intended learning outcomes

Participants have knowledge of the structure and functionality of software-defined networks (SDN). They have the practical ability to configure SDN and to design and program control programs for SDN. They have the practical ability to use existing SDN platforms and tools to develop and test control programs for SDN.

Contents

Introduction to SDN Concepts

SDN standards: OpenFlow protocol

SDN controller architectures and interfaces

recording of network topologies and traffic statistics

Programming of SDN control programs: logically centralized routing protocols, traffic control

Advanced programming concepts for SDN: declarative network programming, programmable packet processing pipelines

Network emulation tools, software switches

SERVICE MANAGEMENT AND CLOUD COMPUTING, AND EVALUATION

Description of study/examination achievements

An exam can be taken in either 46660 OR 72340, not in both modules.

Module cannot be selected in the specialization line!

Description

(Recommended) Requirements

Service Computing

Business Process Management

Intended learning outcomes

The students will learn the basics of systems management and cloud computing.

Contents

Cloud Computing is a fast-growing paradigm for consumption and delivery of IT based services. It is based on concepts derived from consumer internet services, like self-service, apparently unlimited or elastic resources and flexible sourcing options. Many cloud service providers are now offering platforms that assemble services for applications and provide integration into hybrid environments, attracting developer communities and partner ecosystems. Many enterprises rely on service providers for managed services in the cloud.

In this course, we assume familiarity with core cloud technologies and principles as taught in "Cloud Computing - Concepts &;;; Technologies". The cause is taught by practitioners with deep experience in building and managing cloud platform services and cloud solutions, so we will focus on complex use cases and the methods and choices to make them successful.

Topics include

Enterprise requirements on cloud

Cloud migration, transformation of application portfolios for the cloud

Multi-cloud and hybrid cloud, how to build a private cloud

Building complex cloud services – architecture and process considerations, with real-life examples

Cloud management and cloud managed services, SysOps

AI and Big Data in the Cloud

Building an AI-based platform for managed services

Internet of things, connected car

Throughout the course, we will look both at existing products and services as well as the theoretical underpinnings.

The course will be held as a combination of lectures and participant discussion and some hands-on exercises. To gain credit, participants will have to submit a paper of around 10 pages and an oral exam centered on the paper.

DATA ENGINEERING

Intended learning outcomes

The students obtain an overview of the general data engineering process. Selected system-oriented and algorithmic details for each step and component of the data engineering process are covered such that students get detailed knowledge on possible solutions. The discussion enables students to develop data engineering solutions of their own.

Contents

Data engineering involves any data processing necessary to prepare data for subsequent use, eg, for data analysis. This lecture covers foundations, algorithms, and systems on selected topics of data engineering. These include:

Data collection: how do we find relevant data sources?

Big Data integration: Given the unique properties of big data, how can data from multiple data sources be combined to get a more global perspective on a subject to be analyzed?

Data quality and data cleaning: How can important properties and errors of data be assessed and corrected?

Data distribution:What modern technologies support the wide dissemination of data?

Provenance: How can the whole data engineering process be documented, controlled, and improved leveraging so-called meta-data describing the data processing?

THEORETICAL AND METHODOLOGICAL FOUNDATIONS OF AUTONOMOUS SYSTEMS

Description of study/examination achievements

written exam (PL), 120 min, weight: 1

Prerequisites for examination: Practice certificate, criteria will be announced in the first lecture

Description

(Recommended) Requirements

Solid knowledge in linear algebra, probability theory and optimization. Fluency in at least one programming language.

Intended learning outcomes

Students will acquire a conceptual overview of the challenges and research in intelligent autonomous systems. The course will emphasize the necessity of combining theory with integrated systems, namely the theoretical and computational foundations modeling and solving decision and behavioral problems and the integration in real-world autonomous systems that integrate perception, action and (on-board) computation. The course reflects the conceptual structure of the Major in Autonomous Systems by addressing the methodological foundations of (i) Computational Intelligence and Learning, (ii) Perception and Action, and (iii) System Integration.

Contents

This course discusses the challenges and research in intelligent autonomous systems. It introduces to the basic foundations in the relevant disciplines to enable a holistic view on autonomous systems. This is done using a coherent formalization for concepts which are usually introduced separately.

motivation and history

challenges in autonomous systems

frameworks for modeling decisions and behavioral problems

computational methods for solving such problems: planning, decision making

system integration

classical artificial intelligence and modern probabilistic AI

perception and image processing

learning from data (basic regression and classification)

learning applied in autonomous systems (reinforcement learning, adaptive control, system identification)

ADVANCED INFORMATION MANAGEMENT

Description of study/examination achievements

Written (90 min) or oral (30 min) examination

Preliminary examination: written, possibly oral. Details will be announced at the beginning of the event.

Description

(Recommended) Requirements

Knowledge of the basics of databases and information systems, for example from the lecture "Modelling", is assumed.

Intended learning outcomes

Students learn current concepts for modeling, developing, managing and operating database-oriented applications. These include technologies and standards for XML processing and their integration into database systems as well as concepts and systems for content management and data management in the cloud.

Contents

In this event, the following topics will be discussed in particular:

XML and database technology (XML modeling, XML storage, XML query languages, XML processing)

NoSQL data management (Key value stores, MapReduce, triple stores, document stores, graph stores)

Content management (enterprise content management, information retrieval, search technologies)

INFORMATION INTEGRATION

Description of study/examination achievements

[55611] Information Integration (PL), written or oral, 90 min., weight: 1.0

Description

(Recommended) Requirements

Lecture "Modelling" or comparable course

Intended learning outcomes

Integrating heterogeneous, autonomous and structured data is essential in an interconnected world. This is the basis for information exchange and comprehensive search. The goal of this course is to provide an overview of challenges in information integration and to enable the students to assess available approaches and technologies.

Contents

The integration of heterogeneous data sources, ie, combining data residing in different data sources to obtain a global view of the data relating to relevant entities, represents one of the major challenges in data management. Especially in the Big Data era, techniques for automatic, efficient, effective, and scalable integration is key to solving the issue of variety. The problem has been considered for decades, and this lecture will cover foundations of data integration as well as algorithmic and system aspects.

In particular, this course will cover the following topics:

Distribution, autonomy, and heterogeneity as major challenges in data integration.

Types of data integration and associated architectures of integrating systems.

Query processing in integrating systems.

Overcoming schematic heterogeneities between integrated data sources (schema mapping and schema matching).

Getting a unified view of the data using duplicate detection and data fusion.

Description of study/examination achievements

Written (90 min) or oral (30 min) examination

Preliminary examination: written, possibly oral. Details will be announced at the beginning of the event.

Description

(Recommended) Requirements

Knowledge of the basics of databases and information systems, for example from the lecture "Modelling", is assumed.

Intended learning outcomes

The students understand the challenges that arise when integrating data from heterogeneous data sources into a consolidated data warehouse. They know the typical data warehouse architecture and current trends, such as real-time reporting. They also know the structure of a data warehouse and the most important processes for setting one up (extraction, transformation, loading). The students also have an overview of the most important technologies for analyzing data in a data warehouse. This includes reporting, online analytic processing and data mining.

Contents

Among the topics to be discussed in this course are:

Introduction to data warehousing

Data warehouse architecture

Data warehouse design

Extraction, transformation, load

ETL as a service

Introduction to analytics and analytic services

Real-time reporting

Online analytic processing

data mining

INTERNSHIP: ALGORITHMICS

Description of study/examination achievements

[58441] Internship: Algorithmics (LBP), written and oral, weight: 1.0

Description

(Recommended) Requirements

Solid knowledge of data structures & algorithms.

Intended learning outcomes

After successfully completing the module, students should be able to efficiently implement theoretically conceived data structures and algorithms in practice.

Contents

The practical course aims to efficiently implement non-trivial algorithms and evaluate them in practice on non-toy data sets.