Electives III and IV Guide
Artificial Intelligence and Data Science
Winter Semester

Faculty Computer
Science Date: 03.08.2023

TECHNISCHE HOCHSCHULE DEGGENDORF

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AIN-B-13 Databases

Module code	AIN-B-13
Module coordination	Prof. Dr. Ing. Udo Garmann
Course number and name	AIN-B-13 Databases
Original study program	Bachelor Artificial Intelligence
Lecturer	Prof. Dr. Wolfgang Dorner Prof. Dr. Ing. Udo Garmann
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Written ex. 90 min. (specialized exam for M-AID students)
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

After completing the module, students will understand the importance of databases and will be able to differentiate their use. They learn the procedure for creating a data model and can implement it in a concrete database. In this course they learn how to access relational databases with SQL and develop applications based on a database. Students will gain knowledge of performance optimization when storing and accessing data and understand the interaction of application, presentation, and database servers when programming, especially in a web environment.
Specifically, students will have achieved the following learning objectives upon completion of the module:

Subject competency
Students understand the concepts of databases and how to use them.

Social Competence
Exercises will take place as part of the lectures. The students are thus able to understand the database designs of their colleagues, to criticize them and to complement them with their own contributions.

Methodological competence
Students have the ability to create software using a database.

Personal competence
Students are able to implement their own software engineering ideas using databases and defend them against competing approaches

Applicability in this and other Programs

The programming, computer science and software engineering modules build thematically on the module. The module can be used in other study programs such as WI-B and CY-B.

Entrance Requirements

Formal: None
Content: Computer science basic courses e.g. module Fundamentals of Computer Science. Knowledge of a programming language is desirable. Office applications are assumed.

Learning Content

1. Introduction
    1.1. Introduction
    1.2. Why databases?
    1.3. Examples
2. Data modeling
    2.1. Redundancy
    2.2. Data modeling
    2.3. Object oriented
    2.4. Relational data model
    2.5. Normalization
3. SQL
    3.1. SQLite, a database for your pocket
    3.2. SQL Data Definition Language
    3.3. SQL Data Manipulation Language
    3.4. Tables and relations
    3.5. Data models
    3.6. View
4. Advanced concepts
    4.1. Data storage/access targets
    4.2. ACID
    4.3. Sequential data organization
    4.4. Index sequential data organization
    4.5. Relative record organization
    4.6. Optimization
    4.7. Trees
    4.8. Implementations
    4.9. Object relational mapping
5. NoSQL

Teaching Methods

Lectures with exercises.
The share of the accompanying exercise corresponds to approx. 25% of the classroom sessions. To a similar extent to the teaching material, accompanying exercises are provided for consolidation and exam preparation for lecture follow-up.

Recommended Literature

- Thomas M. Conolly, Carolyn E. Begg: Database systems, A practical approach to design, implementation, and managment. Addison-Wesley, an imprint of Pearson Education, 4th edition 2005.
- Kemper A., Eickler A.: Datenbanksysteme: Eine Einführung, Oldenbourg Wissenschaftsverlag
- Preiß, N. (2007), Entwurf und Verarbeitung relationaler Datenbanken, Oldenbourg, München u.a.

FWP-4 Quantum Computing

Module code	FWP-4
Module coordination	Prof. Dr. Patrick Glauner
Course number and name	FWP-4 Quantum Computing
Original study program	X-Katalog FWP AI
Lecturers	Prof. Dr. Patrick Glauner Prof. Dr. Horst Kunhardt
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module (specialized exam for M-AID students)
Language of Instruction	English

Module Objective

This class provides students with an introduction to Quantum Computing (QC), which looks promising to solve certain computational problems substantially faster than classical computers. QC began in the early 1980s and in recent years, investment into QC research has increased in both the public and private sectors. Students will acquire knowledge in QC and its applications in various domains such as machine learning and cryptography. They will also be able to elaborate it further in the future, for example in projects or further studies. Overall, QC is a cutting-edge field, with many high-pay opportunities for graduates.

Applicability in this and other Programs

Miscellaneous

Entrance Requirements

- Programming
- Algorithms and data structures
- Mathematics, in particular linear algebra

Learning Content

- Introduction: history, comparison to traditional computing, applications, business potentials
- Foundations: complex numbers, complex vector spaces

- Systems: deterministic systems, probabilistic systems, quantum systems, assembling systems

- Quantum theory: states, superposition, observables, measuring, dynamics, assembling quantum systems, entanglement
- Architecture: bits and qubits, classical gates, reversible gates, quantum gates, no-cloning theorem
- Selected algorithms: Deutsch's, Deutsch-Jozsa, Simon's, Grover's, Shor?s
- Theoretical computer science: limits of quantum computing, complexityclasses
- Quantum computers and programming: goals and challenges, decoherence, physical realizations, quantum annealing, adiabatic quantum computing
- Applications: quantum machine learning, quantum cryptography, quantum information theory

Teaching Methods

- Lectures
- Seminars
- Discussion of research papers and recent news
- Coursework and case studies, including laboratory problems

Recommended Literature

- P. Glauner and P. Plugmann (Eds.), "Innovative Technologies for Market Leadership: Investing in the Future", Springer, 2020.
- N. S. Yanofsky and M. A. Mannucci, "Quantum Computing for Computer Scientists", Cambridge University Press, 2008.

HPC-M-06 Optimization Methods

Module code	HPC-M-06
Module coordination	Prof. Dr. Peter Faber
Course number and name	HPC-M-06 Optimization Methods
Original study program	Master High Performance Computing / Quantum Computing
Lecturers	Prof. Dr. Peter Faber
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Written student research project
Language of Instruction	English

Module Objective
The students gain an understanding of the construction of modern optimizing compilers and their run-time systems. They understand how certain optimization techniques work, why specific programming patterns may improve performance and others may prohibit optimizations. They are able to apply their knowledge and use appropriate techniques at the appropriate place. Ideally, the students can work on an optimization pass for themselves.

Applicability in this and other Programs
Software design and programming lectures

Entrance Requirements
None

Learning Content
Optimization methods for modern computer architectures are discussed. In particular, theoretical and practical aspects of parallel programming systems for modern high-performance computing systems are highlighted. This includes insights into the inner workings of optimizing compilers and their run-time systems. Optimization methods employed by these compilers are presented and discussed, as well as performance analysis and respective tools.

Teaching Methods
- Lectures, presentations
- lab sessions

- exercises

Recommended Literature

- Klemm, Michael; Cownie, Jim; High Performance Parallel Runtimes -- Design and Implementation. De Gruyter, Oldenbourg. 2021
- Aho; Lam, Monica Sin-Ling; Sethi, Ravi; Ullman, Jeffrey David. Compilers: Principles, Techniques, and Tools (2 ed.). Boston, Massachusetts, USA. Addison-Wesley. 2006
- Further literature as specified during the course

MAI-1 Special Mathematical Methods

Module code	MAI-1
Module coordination	Prof. Dr. Thorsten Matje
Course number and name	MAI-1 Special Mathematical Methods
Original study program	Master Applied Computer Science
Lecturers	Prof. Dr. Thorsten Matje
Duration of the module	1 semester
Module frequency	annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

The students basically deal with methods of probability calculation. They learn the necessary steps to work out independent solutions for corresponding problems in the field of engineering, whereby in particular they are enabled to critically question the selection of the corresponding methods and calculation procedures.

The students achieve the following learning objectives:

Students get to know typical models, methods and tasks from engineering practice, which can be processed with probability theory and statistics, together with corresponding solution methods and strategies. A stochastic way of thinking is anchored.

Professional Skills

The students have knowledge of algebra, analysis and probability theory. In addition, they know the concepts of discrete and continuous random variables. Students are able to work conceptually and methodically. They know the most important discrete and continuous probability distributions and have applied them in practical exercises. In particular, they know the basic assumptions and models behind the individual distributions. They are therefore able to select a suitable probability distribution on the basis of a problem description and to systematically work out the solution on the basis of this distribution. They have the knowledge to interpret data statistically. In summary, the students can apply their acquired knowledge to engineering tasks in a practice-oriented way.

Methodological Skills

Depending on the task, the students are able to identify and successfully apply appropriate calculation methods from a range of calculation methods. They are able to use scientific calculators and probability tables and, if necessary, computer algebra software. The students have the ability to carry out independent research on the basis of extensive exercises and to develop their existing knowledge independently.

Soft Skills

The students are aware of their responsibility as future engineers. They are in a position to discursively question problems among themselves, to justify the solutions argumentatively and to critically evaluate the results of their calculations.

Applicability in this and other Programs

Compulsory subject in Electrical Engineering and Information Technology (Master)
For any other degree programs:
Elective for Master Applied Research in Engineering Sciences
Elective for Master Artificial Intelligence and Data Science

Entrance Requirements

Formally: None

Learning Content

1. Set Theory and Probability
    1.1. Set Operations and Venn Diagrams
    1.2. Applying Set Theory to Probability
    1.3. Relative Frequency, 4-Field-Tableau
    1.4. Probability Axioms
    1.5. Conditional Probability, Law of Total Probability, Bayes Theorem
    1.6. Independent Events
    1.7. Sequential Experiments and Tree Diagrams
    1.8. Counting Methods (Combinatorics)
    1.9. Reliability Problems
2. Discrete Random Variables
    2.1. Discrete Random Variable
    2.2. Probability Mass Funktion (PMF)
    2.3. Cumulative Distribution Function (CDF)
    2.4. Averages
    2.5. Functions of a Discrete Random Variable
    2.6. Derived Random Variables
    2.7. Variance and Standard Deviation
    2.8. Important Discrete Probability Mass Functions
3. Continuous Random Variables
    3.1. Motivation and Overview
    3.2. Probability Density Function (PDF)
    3.3. Expected Value and Variance in the Continuous Case
    3.4. Functions of a Continuous Random Variable
    3.5. Special Continuous Probability Distributions

Teaching Methods

Lectures and seminaristic lessons in alternation, solving problems during the lecture and independent extended training of the computing competence on the basis of weekly exercise sheets, detailed solutions to the exercise sheets are each given with a time delay of one week and are to be compared with the own solutions, if questions arise these are clarified in the lecture.

Remarks

The active participation of the students during the lecture and in the processing of the exercise sheets is particularly important through a discursive style. Challenge and encourage is the motto, so that they are catapulted from an initial passive attitude into a mode of activity.

Recommended Literature

- H. Schwarzlander: Probability – Concepts and Theory for Engineers. Wiley 2011.
- J. A. Gubner: Probability and Random Processes for Electrical and Computer Engineers. Cambridge University Press 2006.
- W. W. Hines / D. C. Montgomery / D. M. Goldsman, C. M. Borror: Probability and Statistics in Engineering, 4th ed. Wiley 2003.
- A. Papoulis / S. U. Pillai: Probability, Random Variables, and Stochastic Processes, 4th ed. McGraw-Hill 2002.
- R. D. Yates / D. J. Goodman: Probability and Stochastic Processes: A Friendly Introduction for Electrical and Computer Engineers. Wiley 1998.

FWP-5 Modern Internet Technologies

Module code	FWP-5
Module coordination	Prof. Dr. Ing. Udo Garmann
Course number and name	FWP-5 Modern Internet Technologies
Original study program	X-Katalog FWP AI
Lecturers	Prof. Dr. Ing. Udo Garmann
Duration of the module	1 semester
Module frequency	Annually, summer semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	PSta
Duration of Examination	
Language of Instruction	English

Module Objective

On a practical web project the students will learn:
- How to start and manage a web project
- How to apply basics of Software Engineering (Requirements, Personas, Use Cases)

Applicability in this and other Programs

Entrance Requirements

Basics of web development: HTML, CSS and Javascript.

Learning Content

2 Stundents work on one web project. The technologies are:
- NodeJS
- MongoDB
- MyGit
- Visual Studio Code
- Frontend with Angular
- Backend with ExpressJS
- Front- and Backend written in Typescript

Teaching Methods

Student research project

Remarks

Recommended Literature

Websites of
- Angular
- Express
- Typescript
- Visual Studio Code
- MyGit

LSI-A1 Biomedical Data Analysis

Module code	LSI-A1
Module coordination	Prof. Dr. Melanie Kappelmann-Fenzl
Course number and name	LSI-A1 Biomedical Data Analysis
Original study program	Master Life Science Informatics
Lecturers	Prof. Dr. Philipp Torkler
Duration of the module	1 semester
Module frequency	Annually, winter semester
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 45 hours Virtual learning: 45 hours Total: 150 hours
Type of Examination	Written student research project
Duration of Examination	90 min.
Language of Instruction	English

Module Objective

This interdisciplinary module combines knowledge from the fields of informatics, statistics and molecular biology.
The *Biomedical Data Analysis* module shows the students the practical application of computer-aided biomedical data analysis and enables them to carry it out independently. This module is an interdisciplinary tutorial in which the students perform the NGS data analysis workflow by themselves under professional instruction.
After completing the Biomedical Data Analysis module, students will have obtained the following learning competencies:

Professional competence

After successfully completing the module, students will:

- have learned how to manage NGS data.
- be familiar with file formats and their usage in the different analysis approaches.
- know about common data analysis workflows and be able to interpret and
- visualize the achieved results.

Methodological competence

After successfully completing the module, students will:

- be able to perform quality control on sequencing data.
- be able to perform mapping procedures and understand the differences between various mapping algorithms.
- be able to create genome indices and know the relevance of a reference genome.
- be able to perform NGS data analysis in terms of RNA-Seq data.

Social competence

- Interdisciplinary and interpersonal collaboration when working together in small groups on performing biomedical data analysis.
- Working together with fellow-students in small groups on designing and developing NGS data analysis workflows.
- Team building by interactive working groups.

Applicability in this and other Programs

Master seminar, master thesis

Entrance Requirements

Advantageous: Module LSI-01: Introduction to Informatics and Biomedicine,
Basic knowledge in R, Basic knowledge in Statistics

Learning Content

1 NGS Data- File Formats
2 NGS-Open Sources
3 Reference Genome
4 Mapping
5 Data Analysis- Genomics
 5.1 Variant Calling
6 Data Analysis- Epigenetics
 6.1 ChIP-Seq
 6.2 Methyl-Seq
7 A practical approach: Data Analysis- Transcriptomics
 7.1 Count Table Generation
 7.2 Differential Expression Analysis
 7.3 Differential Exon Usage

Teaching Methods

Tutorial, practical exercises, application examples
The module consists of an interactive theoretical part with blended learning components. Within the tutorial the students use example NGS datasets to perform the biomedical data analysis workflow. In the practical part of the tutorial the students should learn to find solutions to problems independently by discussions and research work.

Remarks

The iLearn teaching and learning platform provides students with additional literature references and learning material to prepare for the lectures.

Recommended Literature

Detailed lecture notes are available online for preparation and follow-up work
- The Biostars Handbook: Bioinformatics Data Analysis Guide; 2019; https://www.biostarhandbook.com/

FWP-1 Mobile and Wireless Networks

Module code	FWP-1
Module coordination	Prof. Dr. Andreas Kassler
Course number and name	FWP-1 Mobile and Wireless Networks
Lecturer	Prof. Dr. Andreas Kassler
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	undergraduate / postgraduate (additional seminar part for postgraduate)
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 90 hours self-study: 60 hours Total: 150 hours
Type of Examination	Portfolio
Weight	
Language of Instruction	English

Module Objective

Upon completion of the course, students should be able to:

- explain the principles and limitations of wireless communication,

- explain important technical aspects of current wireless communication systems,

- compare and contrast different wireless communication systems based on an understanding of shared challenges (such as mobility management),

- explain the principles of medium access control and why they have been designed in a certain way,

- summarise key functions and principles behind different architectures for mobile and wireless communication systems,

- critically evaluate different properties of a mobile communication system, taking into account design considerations, capacity, and limitations in relation to the technology in question.

Applicability in this and other Programs

The course can be used in Bachelor of Applied Informatics, Bachelor of Internet of Things, CyberSecurity and Bachelor Elektromobilität, autonomes Fahren und mobile Robotik.

It can also be used in Master of Applied Computer Science, Master of Electrical Engineering. In case it is used at MAster Level, Students must complete an additional Seminar part, where they will present a research paper of their choice that is related to the course content and lead a discussion about it.

Entrance Requirements

Students should have basic understanding of computer networks.

Learning Content

The course treats the principles of mobile and wireless, including the function and operation of modern mobile and wireless communication systems and networks related to architecture, protocol, and algorithms. Current wireless systems, such as cellular systems and mobile Internet, including the WLAN standard IEEE 802.11, are used as examples to explain these principles.
The course includes components and exercises that treat these topics in-depth.

The course covers the following:

- Radio signals

- Coding, modulation, and multiplexing

- Medium access

- The basic principles of cellular systems and networks - WLAN (e.g. WiFi) and WPAN (e.g. Bluetooth)

Teaching Methods

- Interactive Lectures

- Interactive Exercise Sessions

- In addition for Master students: They need to read a scientific paper of their choice that suits the course content, present the paper in a workshop and lead a discussion around it

Remarks

Lectures with exercise sessions, where students demonstrate how they solve problems related to class topics.

Recommended Literature

Schiller, Jochen (2003). Mobile Communications (2nd edition). Addison Wesley

Stallings, William and Beard, Cory (2016). Wireless Communications Networks and Systems

FWP-1 Mobile and Wireless Networks

Type of Examination

Portfolio

FWP-10 Imaging Physics

Module code	FWP-10
Module coordination	Prof. Dr. Simon Zabler
Course number and name	FWP-10 Imaging Physics
Lecturer	Prof. Dr. Simon Zabler
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Language of Instruction	English

Module Objective