Technische Hochschule Rosenheim

Module Handbook

Bachelor's Degree Programme

Applied Artificial Intelligence

Winter Semester 2022/23

Content:

Course Descriptions B.Sc. Applied Artificial Intelligence SPO 2021

Aktualisiert am 29.11.2022

Technische Hochschule **Rosenheim**

Applied Artificial Intelligence Bachelor of Science (B.Sc.)

Programme Overview SPO 2021

1st Semester		2nd Semester		3rd Semester		4th Semester		5th Semester		6th Semester		7th Semester	
Winter		Summer		Winter		Summer		Winter		Summer		Winter	
SWS	CP	SWS	CP	SWS	CP	SWS	CP	SWS	CP	SWS	CP	SWS	CP
26	31	26	32	22	27	24	30	4	30	24	29	15	31

1st Semester	2nd Semester	3rd Semester	4th Semester	5th Semester	6th Semester	7th Semester
Programming Basics (6 / 7)	Object-Oriented Programming (4 / 5)	Database Systems (6 / 7)	Software Engineering (4 / 5)	Internship Seminar Part 1 (2 / 3)	Practical Software Engineering (6 / 7)	Computer Vision (6 / 7)
Computer Science Fundamentals (6 / 7)	Theoretical Computer Science (4 / 5)	Unsupervised and Reinforcement Learning (4 / 5)	IT Security (4 / 5)	Internship 18 weeks (0 / 24)	Embedded Artificial Intelligence (4 / 5)	FWPM (8 / 10)
IT Systems (4 / 5)	Introduction to AI Part 2 (4 / 5)	Supervised Learning (4 / 5)	Neural Networks and Deep Learning (4 / 5)		Speech Recognition and Sequence Learning (6 / 7)	
Introduction to AI Part 1 (2 / 2)	Linear Algebra (6 / 7)	Stochastics (4 / 5)	Data Science (4 / 5)		FWPM (8/10)	Bachelor's Thesis (0 / 12)
Analysis 1 (8 /10)	Analysis 2 (4 / 5)	Numerical Methods and Optimization (4 / 5)	Project Management (4 / 5)			
	Digital Business Models (4 / 5)		Computer Law & Ethics for Artificial Intelligence (4 / 5)	Internship Seminar Part 2 (2 / 3)		Bachelor's Thesis Seminar (1 /2)

Modul (SWS / CP) — CP

- Artificial Intelligence
- Computer Science
- Mathematics
- Compulsory Elective Modules
- Internship and Bachelor's Thesis
- Core Competencies / Soft Skills

CP Credit Points
BA Bachelor's Thesis
SWS Semesterwochenstunden ≙ contact hours

Stand: 04.08.21

compulsory modules	abbr.	SWS	CP	name of lecturer in the winter semester 2022/23	type of examination	site
1st semester		**26**	**31**			
Programming Basics	ProgB	6	7	Prof. Dr. Silke Lechner-Greite	written exam 90 min.	49
Computer Science Fundamentals	CSF	6	6	Prof. Dr. Jochen Schmidt	written exam 90 min.	11
IT Systems	IT	4	5	Prof. Dr. Marcel Tilly	written exam 90 min.	37
Intoduction to AI Part 1	AI1	2	2	Prof. Dr. Johannes Jurgovsky		31
Analysis 1	Ana1	8	10	Dr. Sven-Joachim Kimmerle (ANG)	written exam 90 min.	4
2nd semester		**26**	**32**			
Object-Oriented Programming	OOP	4	5	Prof. Dr. Kai Höfig	written exam 90 min + PStA	45
Theoretical Computer Science	TCS	4	5	Prof. Dr. Jochen Schmidt	written exam 90 min.	62
Intoduction to AI Part 2	AI2	4	5	Prof. Dr. Marcel Tilly	written exam 90 min.	33
Linear Algebra	LA	6	7	Prof. Dr. André Herzwurm (ANG)	written exam 90 min.	39
Analysis 2	Ana2	4	5	Dr. Sven-Joachim Kimmerle (ANG)	written exam 90 min.	6
Digital Business Models	DBM	4	5	Prof. Dr. Andreas Krüger	written exam 90 min.	19
3rd semester		**22**	**27**			
Database Systems	DB	6	7	Prof. Dr. Kai Höfig	written exam 90 min.	17
Unsupervised and Reinforcement Learning	URL	4	5	Prof. Dr. Marcel Tilly	written exam 90 min.	64
Supervised Learning	SVL	4	5	Prof. Dr. Johannes Jurgovsky	written exam 90 min.	60
Stochastics	Stoch	4	5	Prof. Dr. André Herzwurm (ANG)	written exam 90 min.	58
Numerical Methods and Optimization	NM	4	5	Prof. Dr. Florian Link (ANG)	written exam 90 min.	41

4th semester		**24**	**30**			
Software Engineering	SE	4	5	Prof. Dr. Ewald Jarz	written exam 60-120 min.	54
IT Security	IST	4	5	Prof. Dr. Reiner Hüttl	written exam 60-120 min. or oral exam 15-45 min.	35
Neural Networks and Deep Learning	NNDL	4	5	Prof. Dr. Jochen Schmidt	written exam 60-120 or oral exam 15-45	43
Data Science	Data	4	5	Prof. Dr. Markus Breunig	written exam 60-120 min. or oral exam 15-45 min.	15
Project Management	PM	4	5	Prof. Dr. Claudia Förster	written exam 60-120 min	52
Computer Law & Ethics for Artificial Intelligence		4	5	Dr. Anita Vrzina	written exam 60-120 min or oral exam 15 min.	23

5th semester		**4**	**30**			
Internship Seminar Part 1	IP1	2	3	Prof. Dr. Marcel Tilly		27
Internship 18 weeks	IP	0	24	Prof. Dr. Marcel Tilly		25
Internship Seminar Part 2	IP2	2	3	Prof. Dr. Marcel Tilly		29

6th semester		**23**	**28**			
Practical Software Engineering	SEP	6	7	Prof. Dr. Gerd Beneken	project	47
Embedded Artificial Intelligence	EAI	4	5	Prof. Dr. Benedikt Dietrich (ING)	written exam 60-120 min or oral exam 15 min.	21
Speech Recognition and Sequence Learning	SRSL	6	7	Prof. Dr. Marcel Tilly	written exam 60-120 min or oral exam 15 min.	56
Required Elective Modules	FWPM	8	10	See list of FWPM		

7th semester		**15**	**31**			
Computer Vision	CV	6	7	Prof. Dr. Jochen Schmidt	written exam 60-120 min or oral exam 15 min.	13
Required Elective Modules	FWPM	8	10	See list of FWPM		
Bachelor’s Thesis Seminar	SeB	1	2	Prof. Dr. Ewald Jarz		9
Bachelor’s Thesis	BA	0	12			8

Descriptions of compulsory modules

Module Name	Abbreviation
Analysis 1	**Ana 1**

Responsible	Lecturer / Examination Type
PD Dr. Sven-Joachim Kimmerle	Check overview from page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: 1st semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	8 hours/week sl	10 ECTS
Workload	Thereof Contact hours	Thereof Independent study
300 h	120 h	180 h

Prerequisites
Compulsory
Good math skills from school, perseverance and endurance
Recommended
-

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know the mathematical structures and methods. They understand the concepts of analysis and are able to apply the mathematical methods to mathematical problems and other applications.
Short module description
This module provides an introduction to the structures and methods of analysis.

Agenda
1. Axiomatic structure of mathematics (number system, axioms of fields, ...) 2. Basic proof principles 3. Convergence analysis on number sequences and series 4. Basic and advanced functions and their properties 5. Differential calculus for functions with one variable 6. Integral calculus for functions with one variable

Reading List & Media
Recommended
J. Hass, C. Heil, M.D. Weir: *Thomas' Calculus.* Pearson, 14th edition, 2019. J. Stewart: Calculus. Brooks/Cole, Canada, 6th edition, 2009.
Additionally recommended
O. Forster: *Analysis 1.* Springer Spektrum, 11. Auflage, 2013. O. Forster: *Analysis 2.* Springer Spektrum, 11. Auflage, 2017.
Media, teaching material
Presentations, practical exercises

Module Name	Abbreviation
Analysis 2	**Ana 2**

Responsible	Lecturer / Examination Type
PD Dr. Sven-Joachim Kimmerle	Check overview from page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: 2nd semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
Analysis ; Parts of Linear Algebra
Recommended
-

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know the mathematical structures and methods. They understand the concepts of analysis and are able to apply the mathematical methods to mathematical problems and other applications.
Short module description
This module provides a continuation to the structures and methods of analysis.

Agenda
1. Convergence analysis for sequences of functions and power series, Taylor and Fourier series 2. Differential calculus in R^n 3. Integral calculus in R^n

Reading List & Media
Recommended
J. Hass, C. Heil, M.D. Weir: *Thomas' Calculus.* Pearson, 14th edition, 2019.
J. Stewart: Calculus. Brooks/Cole, Canada, 6th edition, 2009.

Additionally recommended
O. Forster: *Analysis 1.* Springer Spektrum, 11. Auflage, 2013. O. Forster: *Analysis 2.* Springer Spektrum, 11. Auflage, 2017. O. Forster: *Analysis 3.* Springer Spektrum, 8. Auflage, 2017.
Media, teaching material
Presentations, practical exercises

Module Name	Abbreviation
Bachelor's Thesis	**BT**

Responsible	Lecturer / Examination Type
Supervisors of the thesis	Check on page 1
Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester	
AAI-B: compulsory 7th semester	

Duration	Frequency	Language
1 Semester	frequently	English
Teaching methods	Hours per week	Credit Points
		12 ECTS
Workload	Thereof Contact hours	Thereof Independent study
360 h		

Prerequisites
Compulsory
minimum 160 CP; Internship successfully completed
Recommended
None

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Ability to independently methodically work on an artificial intelligence topic on a scientific basis and to present it in writing.
Short module description
A Bachelor's thesis is the scientific conclusion of a degree. It is intended to show that the graduate is able to work on a problem from his or her degree independently and using scientific methods.
Agenda
The content of the Bachelor thesis depends on the respective topic.

Reading List & Media
Recommended
Depends on the topic of the thesis.
Additionally recommended
Depends on the topic of the thesis
Media, teaching material

Module Name	Abbreviation
Bachelor's Thesis Seminar	**SeB**

Responsible	Lecturer / Examination Type
Prof. Dr. Ewald Jarz	See overview from page 1 / oral exam

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence B. Sc.: compulsory 6th & 7th semester		
Duration	Frequency	Language
2 semester	summer and winter semester	English
Teaching methods	Hours per week	Credit Points
seminar	2 hours per week 1 hour per week per semester	3 ECTS
Workload	Thereof Contact hours	Thereof Independent study
90 h	30 h	60 h

Prerequisites
Compulsory
Applied Artificial Intelligence B. Sc.: at least 80 CP
Recommended
Completed internship semester
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
a) Professional Learning Outcomes: • Methods and approaches to writing a scientific paper. • Researching scientific literature b) Interdisciplinary qualification goals: • Conception and presentation of scientific topics. • Defending scientific work (defensio).
Short module description
The students receive instructions and templates for the preparation of the bachelor thesis and thus appropriate accompanying scientific supervision. Scientific research in online databases, online catalogs and online journals. Working with literature management and word processing systems. The students report, accompanying the bachelor thesis, regularly on the progress of their bachelor thesis. The students present and defend their bachelor thesis.

Agenda

- Introduction to the scientific way of working
- Citation and practical application of the formal requirements for scientific work.
- Scientific research
- Discussion of the conception of the bachelor thesis
- Presentation and defense of the bachelor thesis

Reading List & Media

Recommended

- Hofmann, Angelika: Scientific Writing and Communication: Papers, Proposals, and Presentations.- Oxford: Oxford University Press, 2019
- Heesen, Bernd: Academic Writing in APA-Style: Writing Academic Papers and Theses in APA-Style 7th Edition,- Prescient, 2020
- Bänsch, Axel; Alewell, Dorothea; Moll, Tobias: Wissenschaftliches Arbeiten.- München, u.a.: De Gruyter Oldenbourg, 2020
- Oehlrich, Marcus: Wissenschaftliches Arbeiten und Schreiben.- Berlin; Heidelberg: Springer, 2019
- Theisen, Manuel René: Wissenschaftliches Arbeiten.- München: Vahlen, 2017

Additionally recommended

- Chalmers, Alan: Wege der Wissenschaft.- Berlin; Heidelberg: Springer, 2006
- Dubbe, Hans-Hermann; Beck-Bomholdt, Hans-Peter: Der Hund, der Eier legt: Erkennen von Fehlinformation durch Querdenken, 7. Auflage.- rororo, 2006
- Leopold-Wildburger, Ulrike; Kipman, Ulrike; Reiter, Thomas: Wissenschaftliches Arbeiten 4.0: Vortragen und Verfassen leicht gemacht.- Springer-Lehrbuch, 2017
- Eco, Umberto: How to Write a Thesis.- The MIT Press, 2015
- Alley, Michael: The Craft of Scientific Writing.- Springer, 2018

Media, teaching material

Presentation, elaborated slide sets, research tasks, working with word processing and literature management system.

Event-specific forum in the Learning Campus.

Module Name	Abbreviation
Computer Science Fundamentals	**CSF**

Responsible	Lecturer / Examination Type
Prof. Dr. Jochen Schmidt	Prof. Dr. Jochen Schmidt / written exam

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester

AAI-B: compulsory,1st semester

INF-B: compulsory,1st semester

Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	**Hours per week**	**Credit Points**
seminaristic lecture (sl)	6 hours/week sl	7 ECTS
Workload	**Thereof Contact hours**	**Thereof Independent study**
210 h	90 h	120 h

Prerequisites

Compulsory

none

Recommended

none

Learning Outcomes & Content

Knowledge / Skills / Abilitites / Competencies

The students know and understand important conceptual and theoretical foundations and methods of computer science, especially with regard to the analysis and structuring of technical problems. In the area of coding theory, they acquire in-depth knowledge and skills that enable them to solve problems relevant to practice. They know and understand the current algorithms in the field of cryptography. The ability for social commitment and the evaluation of ethical questions in computer science is achieved.

Short module description

After a brief introduction to computer hardware, the concepts of information as well as number systems and binary arithmetic are covered in depth. This is followed by the principles and algorithms for encoding data, including data compression and encryption methods. The course concludes with an excursion into the basics of graph theory.

Agenda

1. Introduction
   Computer systems, hardware components

2. Message, information and data
   Number systems, representation and conversion
   Binary arithmetic
   Basic concepts of information theory

3. Coding, compression, encryption
   Basic concepts
   Code generation (Huffman/Fano algorithms)
   Fault tolerant codes, Hamming distance, m-out-of-n code, parity
   Hamming code, CRC, Reed-Solomon codes
   Arithmetic coding, run lengths, LZW compression
   Encryption (symmetric/asymmetric methods)
   AES, Diffie-Hellman, RSA, Elliptic curves

4. Graph theory
   Basic concepts (directed and undirected graphs)
   paths, cycles, circles
   Relationship of graphs
   Trees and forests
   depth and breadth search
   shortest paths, A*

Reading List & Media

Recommended

H. Ernst, J. Schmidt und G. Beneken. *Grundkurs Informatik*. Springer Vieweg, 7. Aufl. 2020.

J. Schmidt. *Grundkurs Informatik – Das Übungsbuch: 148 Aufgaben mit Lösungen*. Springer Vieweg, 2. Aufl. 2020.

A. Neubauer, J. Freudenberger, V. Kühn. Coding Theory: Algorithms, Architectures and Applications. Wiley, 2011.

S . Rubinstein-Salzedo. *Cryptography.* Springer Undergraduate Mathematics Series. Springer, 2018.

Additionally recommended

D.W. Hoffmann. *Einführung in die Informations- und Codierungstheorie*. Springer Vieweg, 2014.

C. Paar, J. Pelzl. *Understanding Cryptography: A Textbook for Students and Practitioners.* Springer, 2010.

C. Paar, J. Pelzl. *Kryptografie verständlich: Ein Lehrbuch für Studierende und Anwender.* Springer Vieweg, 2016.

H. Herold, B. Lurz, H. Wohlrab und M. Hopf. *Grundlagen der Informatik*. Pearson Studium, 3. Aufl. 2017.

D. Wätjen. *Kryptographie: Grundlagen, Algorithmen, Protokolle.* Springer Vieweg, 3. Aufl. 2018.

M. Werner. *Information und Codierung: Grundlagen und Anwendungen.* Vieweg+Teubner, 2. Aufl. 2009.

Media, teaching material

Presentations, exercises

Module Name	Abbreviation
Computer Vision	**CV**

Responsible	Lecturer / Examination Type
Prof. Dr. Jochen Schmidt	Check overview from page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: compulsory, 7th Semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	6 hours/week sl	7 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150h	60h	90h

Prerequisites
Compulsory
At least 80 CP
Recommended
Neural Networks and Deep Learning
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know and understand the relevant fundamentals and algorithms of computer vision. They can analyze subject-specific problems in a scientifically sound manner and understand complex interrelationships and implement them in software by selecting suitable methods. They are able to develop new algorithms for computer vision on this basis. They can evaluate and discuss ethical and social implications of their work.
Short module description
This course deals with current methods in computer vision. The focus is on three topics: ▪ Modern image recognition with neural networks/deep learning ▪ Methods for image preprocessing (e.g. filters, also as a basis for Deep Learning) ▪ - Reconstruction of 3D information from multiple images

Agenda
1. Introduction (application examples) 2. Image acquisition methods (color, camera sensors) 3. Image preprocessing: threshold and filter operations (histograms and thresholds, linear and nonlinear filters) 4. Object classification: Convolutional Neural Networks (CNN) 5. Object localization and detection (R-CNN, SSD, YOLO) 6. Image segmentation - classical methods (contour detection) 7. Image segmentation - with Deep Learning (Mask R-CNN, U-Net/Autoencoder) 8. 3D reconstruction and depth (camera calibration, stereo systems).

Reading List & Media
Recommended
Goodfellow, I., Bengio, Y., Courville, A.: *Deep Learning*, MIT Press, 2017. Szeliski, R.: *Computer Vision: Algorithms and Applications*, Springer, 2010. J. Beyerer, F. Puente Leon, Ch. Frese: *Automatische Sichtprüfung*, Springer Vieweg, 2. Auflage 2016.
Additionally recommended
Aggarwal, Ch. C.: *Neural Networks and Deep Learning: A Textbook*, Springer, 2018. A. Nischwitz, M.W. Fischer, P. Haberäcker, G. Socher: *Computergrafik und Bildverarbeitung, Band 2 – Bildverarbeitung*, Springer Vieweg, 4. Auflage, 2020. Gonzalez, R.C., Woods, R.E.: *Digital Image Processing*, Prentice Hall International, 3. Ed, 2008. Hartley, R., Zisserman, A.: *Multiple View Geometry in Computer Vision*, Cambridge University Press, 2. Auflage, 2004.
Media, teaching material
Presentations, exercises

Module Name	Abbreviation
Data Science (AAI)	**Data**

Responsible	Lecturer / Examination Type
Prof. Dr. Markus Breunig	See page 1 / oral exam

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: Compulsory, 4th semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
inverted classroom	4 hours/week	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites

Compulsory

At least 30 CP

Unsupervised Learning, Supervised Learning, Object-Oriented Programming, Linear Algebra, Stochastics

Recommended

Analysis, Database Systems

Learning Outcomes & Content

Knowledge / Skills / Abilitites / Competencies

Technical Skills

Knowledge about the fundamentals processes of data science. How to convert business problems into machine learning/data science problems. Typical methods, algorithms and tools needed to solve exploratory data analysis, analytical and predictive problems. How to approach real-world data science problems with widely used tools (e.g., Jupyter Notebooks). Intermediate knowledge of widely used data science libraries in Python (e.g., pandas, scikit-learn).

Soft Skills

Time management and self-directed learning. Problem solving skills. Discussion skills.

Short module description

We start with an overview of objectives and application areas of data science, and the conceptual fundamentals and processes of data sciences.

Using Jupyter Notebooks, we solve specific data science problems using the most important libraries available for data analysis. The class is very much hands-one, we will be programming extensively in Python.

Agenda
1. Business-Problem vs. Data Science Problem 2. Python, NumPy, pandas, scikit-learn, matplotlib, seaborn 3. Exploratory Data Analysis 4. Data Cleaning, Outliers, Data Munging 5. Modelling 6. Model Evaluation, Cost-Benefit-Matrix 7. Feature Engineering and Hyperparameter Tuning 8. Further Applications

Reading List & Media
Recommended
Provost, Fawcett: *Data Science for Business (2013)* McKinney: *Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython* (2015) Han, Kamber: *Data Mining. Concepts and Techniques*. (2006)
Additionally recommended
Nisbet, Elder, Miner: *Statistical Analysis & Data Mining Applications*. Elsevier (2009)
Media, teaching material
Inverted classroom, hands-on coding in notebooks

Module Name	Abbreviation
Database Systems	**DS**

Responsible	Lecturer / Examination Type
Prof. Dr. Kai Höfig	See page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor compulsory 3rd semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
lecture and exercise	4+2 hours/week	7 ECTS
Workload	Thereof Contact hours	Thereof Independent study
210 h	90 h	120 h

Prerequisites
Compulsory
At least 30 CP
Recommended
All lectures of the first semester, especially programming basics and computer science fundamentals.
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The attendees of this course will learn the fundamental concepts of (relational) database systems. They will be able to master the language SQL interactively and applications.
Short module description
This course provides the basic concepts of databases systems and data models. Especially the relational model is an integral part of this course. Additionally, relational algebra and relational calculus are part of this course. Complementary to the theoretical background, database design using ER-models and an intense training of SQL, the most common database query language, is exercised. Further concepts such as transactions, views, trigger, indexing, and object-relational mapping is part of this course. All topics are discussed during the curse and will be applied in numerous exercises.

Agenda
1. Introduction to databases 2. Relational databases 3. Database design process 4. Relational database design 5. Conceptional design 6. Advanced SQL 7. Relational algebra and tuple relational calculus 8. Domain relational calculus and QBE 9. Transactions, integrity and trigger 10. Views, access control, application development 11. PSM 12. File management and indices

Reading List & Media
Recommended
Hector Garcia-Molina, Jeffrey D. Ullmann, Jennifer Widom: *Database Systems – The Complete Book* (2008)
Additionally recommended
Elmasri, R. and Navathe, S.: *Fundamentals of Database Systems.* Addison Wesley (2006) Korth, H and Silberschatz, A.: *Database System Concepts.* McGraw-Hill (2010) G. Saake, K.-U. Sattler, A. Heuer: *Datenbanken: Konzepte und Sprachen* (2010) Kemper, A. und Eickler, A.: *Datenbanksysteme* (2009)
Media, teaching material
Presentations, practical exercises, project work, hands-on coding

Module Name	Abbreviation
Digital Business Models	**DBM**

Responsible	Lecturer / Examination Type
Prof. Dr. Andreas Krüger	See page 1 / written exam 60-120 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 3rd semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended
Understanding of business administration, controlling and management
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students understand the economic backgrounds behind the internet economy. They can explain market specifics in the internet economy with the help of micro-economic models. They know the „historic“ development of digital business models. Students understand the theoretical background of electronic markets. They can analyse und evaluate existing digital business models with the help of modern methodologies and tools. Participants can develop and optimize innovate digital business models in a structured way, applying suitable methodologies. They will be enabled to transform analog business models into digital business models.
Short module description
Companies like Apple, Amazon, Facebook or Google are some of the companies with the highest market values. Their success is based on their ability to utilize the possibilities which are offered by digital technologies and the internet. At the same time traditional business models are changed fundamentally. Markets that have existed over decades are put into question. In an introductory part students will get familiar with the terminological basics and the building blocks of digital business models as well as with other parts of internet economics. A point of focus will also be the special characteristics of a business startup in an electronic market. After this introduction students develop an understanding of what distinguishes digital from analog goods and services. Based on the identified special characteristics of digital goods their effect on market supply, intermediation, demand structure and pricing mechanisms will be elaborated.

A second major building block of this course is to analyze which market models develop and sustain in a digital and networked world. Example topics are winner-markets, critical mass markets, multi-sided markets, cooperative markets or peer-to-peer markets.

Case studies and various exercises as well as guided preparations and presentations (e.g. group puzzles, expert questionnaires, info markets) will be used during the course.

Agenda

1. Definition of digital business models and distinction from other fields of digital economics
2. Specifics when starting a digital business
3. Fundamentals of electronic markets
4. Production, distribution and consumption in electronic markets
    a. Supply of digital goods
    b. Supply of network goods
    c. Direct and indirect supply-demand-relationships
    d. Strategic pricing in digital markets
5. Digital market models
    a. Winner-markets
    b. Critical mass markets
    c. Bi- and multi-sided markets
    d. Collaborative markets
    e. Peer-to-peer Markets

Reading List & Media

Recommended

Reiner Clement, Dirk Schreiber: Internet-Ökonomie: Grundlagen und Fallbeispiele der vernetzten Wirtschaft, Heidelberg 2016

Tobias Kollmann: E-Entrepreneurship, Wiesbaden, 2016

Frank Frohmann: Digitales Pricing - Strategische Preisbildung in der digitalen Wirtschaft mit dem 3-Level-Modell, Wiesbaden 2018

Christian Hoffmeister: Digital Business Modelling: Digitale Geschäftsmodelle entwickeln und strategisch verankern, München 2015

Additionally recommended

Additional material will be recommended during the lecture:

Online:

Prof. Dr. Daniel Schallmo "Die Digitale Transformation von Geschäftsmodellen erfolgreich gestalten.": https://www.youtube.com/watch?v=jr5iQMiiC_k&t=2s

Christian Hoffmeister „Digitales Geschäftsmodell von Netflix erklärt mit dem DVC-Framework“: https://www.youtube.com/watch?v=lwqhYAg2-Ts

Michael Jaekel: Die Anatomie digitaler Geschäftsmodelle, Wiesbaden 2015

Media, teaching material

Presentations, exercises

Module Name	Abbreviation
Embedded Artificial Intelligence	**EAI**

Responsible	Lecturer / Examination Type
Prof. Dr. Benedikt Dietrich	Check overview on page 1 / written exam 60-120 min or oral exam 15 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 6th semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	2 hours /week sl 2 hours / week lab course	5 ECTS
Workload	Thereof contact hours	Thereof independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 80 CP
Recommended
Supervised Learning, Unsupervised and Reinforcement Learning, Practical Software Engineering
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Upon the end of the module students will have attained the competencies to… • Understand the challenges of AI applications for embedded systems • Analyze AI algorithms regarding computational effort, memory, timing and power consumption • Partition AI applications to edge, edge server and cloud • Port AI algorithms to embedded devices • Understand specialized hardware architectures to accelerate AI algorithms • Accelerate AI algorithms using specialized hardware • Optimize and deploy algorithms on embedded systems
Short module description
In the first part of the module challenges of brining AI to the edge and limiting factors of embedded systems are identified. Algorithms are analyzed with regards to computational complexity, memory footprint and timing. As of today typical AI applications are split across

edge, edge server and cloud. Distributed architectures are discussed and advantages and disadvantages identified by example.

The second part of the lecture focuses on hardware acceleration of AI applications on embedded devices. Different classes of embedded hardware and accelerators (TPU, DSP, FPGA, …) are introduced, analyzed and limiting factors identified.

In the third part of the lecture the students will learn about algorithmic as well as software optimizations that are typically applied to further speed up computations on embedded systems.

In addition to the lecture there will be practical exercises and lab courses allowing students to bring AI algorithms to life on different embedded systems and analyze the results.

Agenda

1. Introduction and challenges of Embedded AI
2. Resource requirements of AI Algorithms
3. Distributed AI Application Architectures
4. Embedded AI Hardware Architectures
5. Hardware Accelerators for AI Computations (FPGA, TPU, GPGPU, DSP)
6. Optimizing AI Algorithms for Embedded Systems
7. Software Frameworks for Embedded Systems
8. Algorithmic Optimizations for Embedded Systems
9. Software Optimizations for Embedded Systems

Reading List & Media

Recommended

Pete Warden, Daniel Situnayake *„TinyML – Machine Learning with TensorFlow Lite on Arduino and Ultra-Low-Power Microcontrollers“*, O'REILLY, 2020.

Additionally recommended

Media, teaching material

Presentations, practical exercises, project work, hands-on coding

Module Name	Abbreviation
Ethics of Artificial Intelligence	

Responsible	Lecturer / Examination Type
Dr. Anita Vrzina	See page 1 / written exam 60-120 min or oral exam 15 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 4th Semester		
Duration	Frequency	Language
1 Semester		English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	2 hours /week sl	2,5 ECTS
Workload	Thereof contact hours	Thereof independent study
90 h	30 h	60 h

Prerequisites
Compulsory
At least 30 CP
Recommended
none
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
After completing this course, students will be able to critically evaluate ethical principles and strategies and apply them to the ethical issues in the business environment and computer science with a special emphasis on the field of artificial intelligence and AI technologies. Students will be able to demonstrate understanding of philosophical issues involved in ethics of artificial intelligence; understand different grades of AI systems and their ethical implications; distinguish between the potential and existing risks pertaining to AI; have the ability to express coherent argument about ethics for AI systems and deep learning neural networks clearly and concisely; show ability to work in a small team; show ability to produce written work regularly to a deadline; gain skills in research, analysis, and argumentation.
Short module description
The course explores the topics of technology, AI, and ethics in the business environment and their application in communicative situations in an international context. It aims to provide students with the skills to understand and deal with ethical questions in different business environments both within the company and in the international arena often called “the global village” with the focus on the following aspects of ethics with regard to AI: • What is the ethics of AI? • Singularity and superintelligence • Motivation and instrumental rationality in AI systems

- AI and bias
- Ethics and autonomous weapons
- Automation at the workplace
- Autonomous driving
- Robot rights

Agenda

Students will first be introduced to different approaches to ethics and analyze the concepts of value, morality, as well as cultural norms and upbringing. In the second part of the course, students will explore the application of these theoretical approaches to the field of artificial intelligence with the focus on the following questions:

- How do we align the aims of autonomous AI systems with our own?
- Does the future of AI pose an existential threat to humanity?
- How do we prevent learning algorithms from acquiring morally objectionable biases?
- Should autonomous AI be used to kill in warfare?
- How should AI systems be embedded in our social relations?
- What sort of ethical rules should AI like a self-driving car use?
- Can AI systems suffer moral harms? And if so, of what kinds?
- Can AI systems be moral agents? If so, how should we hold them accountable?
- How should we live with and understand minds that are alien to our own?

Reading List & Media

Recommended

Bauer, W. A. (2020). Virtuous vs. utilitarian artificial moral agents. AI and Society.

Etzioni, A., & Etzioni, O. (2016). AI assisted ethics. Ethics and Information Technology.

Additionally recommended

Bryson, J. J. (2018). Patiency is not a virtue: the design of intelligent systems and systems of ethics. Ethics and Information Technology.

Floridi, L. (2016). Faultless responsibility: On the nature and allocation of moral responsibility for distributed moral actions. Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences, 374(2083), 1–13.

Feng, Z. (2018). Does AI Share same ethic with human being?: From the perspective of virtue ethics. IFIP Advances in Information and Communication Technology.

Hagendorff, T. (2020). The Ethics of AI Ethics: An Evaluation of Guidelines. Minds and Machines.

Hooker, J., & Hooker, J. (2018). Ethics of Artificial Intelligence. In Taking Ethics Seriously.

Mittelstadt, B. (2019). AI Ethics – Too Principled to Fail? SSRN Electronic Journal.

McDermott, D. (2008). Why ethics is a high hurdle for AI. North American Conference on Computers and Philosophy (NA-CAP).

Media, teaching material

Presentation with projector and blackboard, exercises, homework, case study

Module Name	Abbreviation
Internship	**IS**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	check overview on page 1

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 5th Semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
	-	24 ECTS
Workload	Thereof Contact hours	Thereof Independent study
min. 18 weeks	-	-

Prerequisites
Compulsory
At least 80 CP and it applies Z2 Z2) Only those who have attended the Internship Seminar Part 1 (No. 29) are authorised to take the supervised practical phase (Internship, No. 31).
Recommended

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students gain insights into the connections between practical training and studies during a challenging project. In the area of interdisciplinary qualifications, students learn about working in a team and cooperating with peers, superiors and ideally customers, thereby sharpening the skills learned in internship seminar 1 (such as communication & conflict, business etiquette, presentation, etc.). They gain insight into the technical and organisational contexts, structures and processes of a company, as well as into the sociological problems of a typical company and apply the knowledge from block 1 to solve them. On the technical side, the students deepen the basics learned in the first two years of study and apply them to real problems in practice. They gain insight into engineering activities through concrete tasks and the practical solution of tasks from the field of computer science, data science and AI. You will get to know the engineering activities in the area of planning, implementation and maintenance of AI projects. The activities carried out build on the fundamentals taught in the subjects of the first four semesters, place these in the context of the concrete employer/project and expand them with customer and activity-specific aspects.

The students learn to independently build up missing, further knowledge.
Short module description
The practical period can be completed at employers with a clear AI connection, e.g. at manufacturers, medical, automotive and software houses. The interns themselves are responsible for finding a suitable internship position in good time. The Faculty of Computer Science will assist as far as possible. A contract is to be concluded with the employer according to the model available from the Internship Office. The period of 18 weeks is to be carried out contiguously during the internship semester. It is also recommended to find an internship position outside of Germany. In any case a report must be prepared at the end of the internship semester. The internship report must be submitted on time and must meet the requirements communicated in internship seminar 1. After the assessment "passed" or "failed", the practical report is returned to the student. In the case of the assessment "not passed", a rectification is required.

Agenda
Depends on the internship and tasks in the company

Reading List & Media
Recommended
-
Additionally recommended
-
Media, teaching material
Min 18 weeks of internship

*At least 18 weeks; only approx. 30 working hours per week are credited to the higher education studies, as there are also activities in the company that are not directly attributable to the studies.

Module Name	Abbreviation
Internship Seminar Part 1: Key Skills Qualification	**IS1**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	check overview on page 1

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: compulsory, 5th Semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	2 hours/week sl	3 ECTS
Workload	Thereof Contact hours	Thereof Independent study
90h	30h	60h

Prerequisites
Compulsory
none
Recommended
none
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Awareness of the importance of interdisciplinary key skills (social competence, methodological competence, self-competence). Knowledge of central theoretical principles of various soft skills that are important in preparation for the internship, ability to reflect on one's own key competences. Acquiring practical experience especially in the area of social and methodological competences (communication, negotiation techniques, conflict management, teamwork, presentation) Understanding and knowledge of complex social structures and processes in companies Awareness and understanding of ethical issues with regard to new technologies and their influence on social and economic developments.
Short module description
This course is intended for students of AAI-B who have completed the 4th semester and are in the preparation phase for their internship. It serves as targeted preparation for the practical phase with regard to the necessary social, methodological and personal skills. After the development of the interdisciplinary key skills relevant to one's own professional life, there is first a theoretical introduction to some key basics. The focus here is on teaching basic models of communication psychology (Watzlawick, Schulz von Thun) and basic communication

and presentation techniques. On the basis of this knowledge, a practice-oriented deepening of the particularly relevant key topics then takes place (partly in smaller groups).

After the internship, the participants reflect on the knowledge gained in relation to their experiences in the company by means of a question-oriented presentation.

Agenda
Main topics 1. Communication and conflict management (recognising the root causes of conflicts, learning how to deal with conflicts) 2. Teamwork (experiencing the advantages of successful and productive work in a team, recognising the success factors for teamwork, learning how to work in a team) 3. Business etiquette (learning rules of conduct in companies) and dealing with technology from an ethical point of view 4. Scientific writing (instruction on how to write a practical report) 5. Presentation (practical training of one's own presentation skills with regard to target group orientation, personal charisma, rhetoric and visualisation). Finally, the findings from the individual key topics are summarised in the plenum and transferred into a concrete task (guiding questions) for the internship.

Reading List & Media
Recommended
To be announced in each course
Additionally recommended
To be announced in each course
Media, teaching material
Lecture, small group work, discussions, practical exercises, role plays, (video) feedback

Module Name	Abbreviation
Internship Seminar Part 2: Practical reports and presentation	**IS2**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	check overview on page 1

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 5th Semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
internship	2 hours/week presentation	3 ECTS
Workload	Thereof Contact hours	Thereof Independent study
90h	10h	80h

Prerequisites
Compulsory
At least 80 CP and Z3 Z3) Only those who have attended the Internship Seminar Part 1 (No. 29), completed the supervised practical phase (Internship, No. 31) and submitted the practical report are authorised to participate in the Internship Seminar Part 2 (No. 30).
Recommended
none
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Ability to reflect on the practical applicability of the key competences learned in Internship Seminar 1. Confident use of the presentation skills learned in Internship Seminar 1. Broad insight into IT applications in practice. Ability to write a scientific report as a result of the internship.
Short module description
Following the practical phase, the participants reflect on the knowledge gained in relation to their experiences in the company. In particular, the application of the key skills learned in block 1 is addressed in the internship. The written practical reports are submitted, presented and evaluated. The presentations are scrutinised for relevance to the key competences and discussed in feedback rounds.

Agenda
→ Writing a practice report → Giving a presentation → Group discussion.

Reading List & Media
Recommended
Check Internship Seminar Part 1
Additionally recommended
Check Internship Seminar Part 1
Media, teaching material
Small group work, discussions, practical exercises, feedback

Module Name	Abbreviation
Introduction to AI - Part I	**AI1**

Responsible	Lecturer / Examination Type
Prof. Dr. Johannes Jurgovsky	Check overview on page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 1st semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	2 hours/week sl	2 ECTS
Workload	Thereof Contact hours	Thereof Independent study
75 h	30 h	45 h

Prerequisites
Compulsory
None
Recommended
None
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students obtain access to the underlying motivation of artificial intelligence, its history, success stories and limits. Students know and understand the theoretical and algorithmic foundations of AI. They are familiar with discrete environments, classic AI algorithms and means to represent knowledge about the environment. They can evaluate and discuss ethical and social implications of AI.
Short module description
Artificial Intelligence is a broad topic and covers much more than just deep learning elements. This module provides an introduction to the field of artificial intelligence. Foundations, basic logic and intelligent approaches are covered in scope of this module. Thus, students acquire the first theoretical and algorithmic foundations of the broad field of artificial intelligence.

Agenda
1. Introduction and Overview 2. Problems and Domains of AI 3. History of AI 4. Agents and Environments 5. Search and Ranking 6. Knowledge Representation 7. Reasoning 8. Planning 9. First-order Logic and Rule-based Systems 10. Uncertain Knowledge and Reasoning 11. Philosophy, Ethics, and Safety of AI

Reading List & Media
Recommended
Norvig, P.; Russel, S.: *Artificial Intelligence: A Modern Approach*, Pearson, 2016 Ertel, W.: *Introduction to Artificial Intelligence*, Springer, 2018
Additionally recommended
Flasiński, M.: *Introduction to Artificial Intelligence*, Springer, 2016
Media, teaching material
Presentations, exercises

Module Name	Abbreviation
Introduction to AI - Part II	**AI2**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	Check overview on page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 2nd semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
None
Recommended
None
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know about problem domains, applications and foundations of artificial intelligence. Students know and understand the theoretical and algorithmic foundations of knowledge representation and reasoning, problem solving, and AI in general. Students learn to implement solutions for specific problems with Python. They can analyze difficult subject-specific problems in a scientifically sound manner and understand complex interrelationships and implement them in software by selecting suitable methods. They can evaluate and discuss ethical and social implications of their work in scope of AI.
Short module description
This module of Artificial Intelligence covers most advanced topics of AI. Students acquire the theoretical and algorithmic foundations of the broad field of artificial intelligence: search and ranking, knowledge representation and reasoning, planning and logic and first introduction into machine learning. The second part of introduction into AI is a practical oriented and is sing Python for programming exercises.

Agenda

1. Introduction and Overview
    a. Introduction into Python
2. Problem solving
    a. Search in Complex Environments
    b. Game Theory
    c. Constraint Satisfaction Problems
3. Knowledge representation
    a. Ontologies
    b. Inference in First-Order Logic
    c. Automated planning
4. Uncertain knowledge and reasoning
    a. Acting under uncertain conditions
    b. Probabilistic reasoning
    c. Probabilistic programming
5. Introduction into Machine Learning
    a. Perception
    b. NLP

Reading List & Media
Recommended
Norvig, P.; Russel, S.: *Artificial Intelligence: A Modern Approach*, Pearson, 2016 Artasanchez, A.: *Artificial Intelligence with Python: Your complete guide to building intelligent apps using Python*, Packt, 2020
Additionally recommended
Ertel, W.: *Introduction to Artificial Intelligence*, Springer, 2018.
Media, teaching material
Presentations, exercises

Module Name	Abbreviation
IT Security	**ITS**

Responsible	Lecturer / Examination Type
Prof. Dr. Reiner Hüttl	See overview from page 1 / oral exam 15 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester

Informatik Bachelor: compulsory 6th semester

Applied Artificial Intelligence Bachelor: compulsory 4th semester

Wirtschaftsinformatik Bachelor: FWPM / 6th – 7th semester

Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	**Contact hours per week**	**Credit Points**
seminaristic instruction (si)	2 chw si 2 chw laboratory course	5 ECTS
Workload	**Thereof Contact hours**	**Thereof Independent study**
150 h	60 h	90 h

Prerequisites

Compulsory

INF-B, AAI-B, WIF-B: at least 80 CP

Recommended

none

Learning Outcomes & Content

Knowledge / Skills / Abilitites / Competencies

Students are able to assess IT Systems according to security criteria and apply measures to increase IT Security.

They acquire comprehensive knowledge in methods for the systematic construction of secure IT Systems and Software and can implement this in real systems.

Students will know the impact of poor IT security and Data Protection on society and will thus be empowered for social engagement.

Through interactive teaching elements and group work, students' ability to discuss security topics is strengthened.

Short module description

Information security addresses an area that affects everyone who creates, operates, or uses IT systems. With the tremendous growth of distributed computing systems, their increasing interconnections through networks, and the dependence of businesses on information, IT security takes on a central role as a cross-cutting issue relevant to all computer scientists.

The course covers the fundamentals and modern techniques in information security. The focus is on the application of the techniques and the associated processes in real IT systems. Topics covered include: Data Encryption, User Authentication, Public-Key Infrastructures (PKI), Digital

Signatures, Security in Distributed Systems and Networks, Programming Secure Software, Secure Software Engineering, Data Protection, Impact of Poor IT Security and Lack of Data Protection on Society

Agenda

1. Motivation, goals
2. Encryption
   (Symmetric and asymmetric encryption, key management, practical aspects of encryption)
3. Checksums and Digital Signatures
   (Hash functions, MAC, signature methods, signature law, practical aspects of signatures, PKI, certificates)
4. Authentication, Authorization
   (authentication methods, biometrics, practical aspects in authentication, access control, RBAC, RuBAC, ABAC)
5. Application security
   (OWASP TOP 10, SQL injection, Cross-Site Scripting, approaches to secure software development)
6. Secure software engineering
   (analysis of security requirements, security architecture, security patterns, toos for security analysis)
7. Secure communication
   (VPN, TLS, WLAN)
8. Data protection and privacy
   (GDPR, principles of data protection, distinction between data protection and data security, impact of data protection, privacy and data security on society)

Reading List & Media

Recommended

Andress, Jason.: *Foundations of Information Security*. O'Reilly (2019)

Wong, David.: *Real-World Cryptography*. Manning Publications Company (2021)

Schneier, Bruce: *Applied Cryptography*. Wiley (2015)

Additionally recommended

Bock, Lisa: *Modern Cryptography for Cybersecurity Professionals*. Packt Publishing (2021)

Calder, Alan: *The Cyber Security Handbook.* IT Governance Ltd. (2020)

Mitnick, Kevin: *The Art of Invisibility*. mitp (2017)

Ericson, Jon: *Hacking, The Art of Exploitation*, No Starch Press (2008)

Ferguson, N., Schneier, B., Tadayoshi K.: *Cryptography Engineering*. Wiley (2010)

Media, teaching material

Presentation with projector and blackboard, practical exercises with programming, tools, examples, case studies to deepen the subject

Module Name	Abbreviation
IT Systems	**IT**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	Check overview on page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 1st semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150h	60h	90h

Prerequisites
Compulsory
none
Recommended
none

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know architecture and processor alternatives of modern computer systems and can assess how individual aspects of the architecture can influence the performance of a system. Students can use modern operating systems and apply them effectively. They can explain how data is communicated between systems and they are able to explain how packet-switching systems work. Students know the concept of protocols and layers and know how to assign individual data communication tasks to the correct layers. They can explain which technologies are used in the local network and the Internet and can use them in their own applications. Furthermore, students can explain the technical basics of Internet technologies and assess which effects and possibilities they have in companies.
Short module description
This module teaches the basis of IT systems from individual computers to distributed systems in the cloud. The focus is on practical application and programming. Based on the von-Neumann computer architecture, the basic structure and functioning of a computer are explained. The students learn the basics of circuit networks and the logical structure of a computer. The basic interaction of the various components in a computer is taught and tested.

Furthermore, how different operating systems work on IT systems, i.e. how they handle resources and execute programs. The focus is on shell commands and the implementation in corresponding batch processing programs. In addition to the basics, an overview of different processor architectures is also provided (e.g. x86 vs. ARM).

Since today's IT systems are rarely local single-computer systems, it is worth taking a look at distributed systems and computer networks. Thus the basics of network and internet technologies are examined. The students learn about the basic technologies of the Internet and how to use them in their own applications. They gain an understanding of the technical structure of web applications and learn to implement simple web applications. The students also get to know and use modern cloud systems and technologies.

Agenda

1. Basics of hardware concepts and computer architectures (von-Neumann Architecture)
2. Logical design of computers and switching networks
3. Computer structures, bus concepts, arithmetic logic unit, control unit, memory, input/output
4. Introduction to processor architecture with examples of x86 and ARM
5. Introduction to operating systems using examples of Windows and Linux
6. Networks
7. Distributed applications
8. Internet technologies: protocols, concepts and architectures
9. Basic technologies of the World Wide Web (WWW)
10. Concepts and realisation of web applications
11. Cloud architectures/technologies

Reading List & Media

Recommended

Tanenbaum, Andrew S.: *Computer Networks*, Pearson (2013)

Sunyaev, Ali,: *Internet Computing: Principles of Distributed Systems and Emerging Internet-Based Technologies*, Springer (2020)

Ledin, Jim: *Modern Computer Architecture and Organization*, Packt(2020)

Additionally recommended

Tanenbaum, A.S. und Goodman, J.: *Structured Computer Organization*. Prentice Hall (1997)

Tilkov, S.: *REST und HTTP*, dpunkt Verlag (2009)

Media, teaching material

Presentations, exercises

Module Name	Abbreviation
Linear Algebra	**LA**

Responsible	Lecturer / Examination Type
Prof. Dr. André Herzwurm	Check overview on page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory, 2nd Semester		
Duration	Frequency	Language
1 semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	6 hours/week sl	7 ECTS
Workload	Thereof Contact hours	Thereof Independent study
210 h	90 h	120 h

Prerequisites
Compulsory
-
Recommended
Analysis I

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know the basic mathematical structures and methods. They understand the basic concepts of linear algebra and are able to apply the mathematical methods to mathematical problems and other applications.
Short module description
This module provides a basic introduction to the structures and methods of linear algebra.

Agenda
1. Vector spaces, bases, and dimension 2. Matrices, linear maps, matrix representation of linear maps, and change of basis 3. Systems of linear equations 4. Determinants, eigenvalues, and diagonalization 5. Inner product spaces, orthogonal projection, and spectral theorem for symmetric matrices

Reading List & Media
Recommended
Linear Algebra Done Right, Sheldon Axler, Springer, 2015, ISBN 978-3-319-11079-0 Lineare Algebra, Gerd Fischer, Springer, 2014, ISBN 978-3-658-03945-5 (in German) Linear Algebra, Jörg Liesen and Volker Mehrmann, Springer, 2015, ISBN 978-3-319-24344-3
Additionally recommended
-
Media, teaching material
Presentations, videos, practical exercises

Module Name	Abbreviation
Numerical Methods and Optimization	**NM**

Responsible	Lecturer / Examination Type
Prof. Dr. Florian Link	Check overview on page 1 / written exam 60-120 min. or oral exam 15 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: 4th semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lectures (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended
Analysis 1+2, Linear Algebra, some basic programming skills

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The students know, understand and can apply the following numerical methods 1. Implementation of easy numerical algorithms in Octave/Matlab and analysis of their convergence, stability and computational burden 2. Linear Equation Systems: Decomposition methods (LU, Cholesky) and iterative methods (Jacobi, Gauss-Seidel) 3. Nonlinear Equation Systems: Newton's method 4. Linear and nonlinear least squares, Levenberg-Marquardt algorithm 5. Linear Optimization, Simplex method
Short module description
Introduction to numerical methods and their implementation on the computer. Topics include solving big linear and nonlinear equation systems, finding best model functions for data sets and optimization.

Agenda
1. Introduction to numerical methods and Octave/Matlab 2. Linear Equation Systems: Decomposition methods (LU, Cholesky) and iterative methods (Jacobi, Gauss-Seidel) 3. Nonlinear Equation Systems: Newton’s method 4. Linear and nonlinear least squares, Levenberg-Marquardt algorithm 5. Linear Optimization, Simplex method

Reading List & Media
Recommended
S. Butenko, P. M. Pardalos: “Numerical Methods and Optimization - An Introduction”, CRC Press (2014) C. Chapra, R. P. Canale: „Numerical Methods for Engineers“, McGraw Hill (2015) J.N. Kutz: „Data-Driven Modeling and Scientific Computation“, Oxford University Press (2013)
Additionally recommended
Media, teaching material
Presentations, practical exercises, project work, hands-on coding

Module Name	Abbreviation
Neural Networks and Deep Learning	**NNDL**

Responsible	Lecturer / Examination Type
Prof. Dr. Jochen Schmidt	Check overview from page 1 / written exam 60-120 min or oral exam 15-45 min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 4th semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended
Supervised Learning
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know and understand the theoretical and algorithmic foundations of Deep Learning. They can analyze difficult subject-specific problems in a scientifically sound manner and understand complex interrelationships; they are able to implement them in software by selecting suitable methods. They can evaluate and discuss ethical and social implications of their work.
Short module description
The course covers foundations of Deep Learning with neural networks.

Agenda
1. Feedforward neural networks: Multi-Layer Perceptron (MLP) 2. Loss functions and Optimization 3. Convolutional Neural Networks (CNN) 4. Regularization 5. Training strategies and evaluation, architecture selection, hyperparameter optimization 6. Recurrent neural networks (RNN, LSTM, GRU) 7. Unsupervised learning: Autoencoders 8. Generative Adversarial Networks 9. Self-supervised Learning 10. Visualization: network architecture, training, parameters

Reading List & Media
Recommended
Goodfellow, I., Bengio, Y., Courville, A.: *Deep Learning*, MIT Press, 2017. (online verfügbar: http://www.deeplearningbook.org/) Aggarwal, Ch. C.: *Neural Networks and Deep Learning: A Textbook*, Springer, 2018.
Additionally recommended
-
Media, teaching material
Presentations, exercises

Module Name	Abbreviation
Object-Oriented Programming	**OOP**

Responsible	Lecturer / Examination Type
Prof. Dr. Kai Höfig	Check overview on page 1 / written exam 60-120 min + PStA*

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: compulsory / 2nd semester		
Duration	Frequency	Language
1 semester	summer semester	English
Teaching methods	Hours per week	Credit Points
lecture and exercise	2+2 hours/week	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
Programming basics
Recommended
All lectures oft the first semester

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The participants of this course specialize in all concepts of object-oriented programming and extend their basic programming skills. Using professional tooling and an integrated development environment, complex projects can not only be developed object-oriented but also tested, analyzed and handled using version control. Using the exercise, a sound programming style is trained and during a self-defined project, the participants learn how to solve complex problems using object-oriented programming.
Short module description
This course builds upon the lecture programming basics and expands the previously introduced object-oriented concepts. Then most important elements of object-oriented programming such as classes, objects, interfaces, inheritance, polymorphism are trained intensely. Based upon that, most important data structures such as container and iterators are examined together with the algorithms to interact with this data structures. Topics such as recursion, software test, documentation, common sorting algorithms and programming conventions are also part of this course and are not limited to object-orientation. The topics of this course are trained intensively during exercises using a modern environment from the beginning and are extended by a compulsory programming project that has to be developed as a group.

Agenda
1. Professional software development, specification, versioning, exception handling 2. Data structures, list, set, map, iterator, generics 3. Algorithms, iteration, recursion, sorting 4. Data processing using container 5. Abstract classes 6. Design patterns 7. Parallel execution

Reading List & Media
Recommended
Joshua Bloch: Effective Java, Addison-Wesley Professional; 3. Edition (27. Dezember 2017), □ ISBN-13 : 978-0134685991 Ullenboom, Ch.: *Java ist auch eine Insel.* 12. Auflage. o.O.: Rheinwerk Computing, 2016. Sierra, K., Bates, B.: *Java von Kopf bis Fuß.* o.O.: O'Reilly, 2006.
Additionally recommended
Gamma, E. et al.: *Design Patterns*. Addison Wesley (1994)
Media, teaching material
Presentations, practical exercises, project work, hands-on coding

PStA = Prüfungsstudienarbeit *coursework (such as a work experience report, or a colloquium for group work with an additional, individual examination)*

Module Name	Abbreviation
Practical Software Engineering	

Responsible	Lecturer / Examination Type
Prof. Dr. Gerd Beneken	Check overview on page 1 / PStA*
Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester	
Applied Artificial Intelligence Bachelor: compulsory / 6th semester	

Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	**Hours per week**	**Credit Points**
project work + lectures	6 hours/week	7 ECTS
Workload	**Thereof Contact hours**	**Thereof Independent study**
210 h	90 h	120 h

Prerequisites

Compulsory

At least 80 CP and Z1

Z1) Only those who have passed the examination in Software Engineering (No. 16) and successfully completed the supervised practical phase of the practical semester (Internship, No. 31) can take the Practical Software Engineering module (No. 22).

Recommended

Learning Outcomes & Content

Knowledge / Skills / Abilitites / Competencies

The students can conduct software development projects independently in a small team. On completion of the course, the student should be able to:

- Run the project with their student peers using scrum and xp practices.
- Specify the product requirements using first conversations with the customer
- Analyze the requirements to find a minimal viable product
- Define the software architecture of a simple product
- Implement a product in a programming language such as java, javascript, go or python
- Conduct exploratory testing
- Implement automated unit and acceptance tests
- Apply continuous integration and delivery

Short module description

The students conduct a real world software engineering project. Customer a usually companies from the greater Rosenheim Area (Munich, Salzburg) or research projects. All projects apply methods in artificial intelligence, such as image processing, image understanding, or natural language understanding. An OCR component that scans and understands German vehicle registration forms is an example.

A project starts with first ideas of a product. These ideas are discussed with a real customer. At the end of the Semester a minimal viable product (MVP) is delivered to the customer by the team.

Agenda

1. Basics of scrum and agile development
   Scrum flow, kanban flow
   Retrospectives
   Sprint review meetings
2. Practices in software engineering
   Configuration management using git
   Organizing a team using agile methods and gitlab (task board, issues, wiki)
3. Agile requirements engineering
   Maintaining the product backlog
4. Software architecture
   Architectural drivers
   Guiding principles
   Documenting architectures, views, viewpoints, concerns, uml 2.x
5. Implementation
   Test driven development, refactoring
   Code reviews, merge requests and static analysis
6. Software quality assurance
   Product risk assessment
   Automated tests, unit tests, test automation strategy
   Exploratory testing
7. Integration and delivery
   Acceptance tests
   Delivery documentation
8. Maintenance and IT-Operations

Reading List & Media

Recommended

Beneken, Kucich, Hummel: „Agile Software-Technik“, Springer 2021

Additionally recommended

Sutherland, Jeff: Doing twice the work in half the time, Currency, 2014

Brooks, F.: Mythical man month, Addison-Wesley, 1975

DeMarco, T., Lister T.: Peopleware, Productive Projects and Teams, 3rd edition, Addison-Wesley, 2016

Media, teaching material

Presentations, online videos, project work, hands-on coding

*PStA = Prüfungsstudienarbeit *coursework (such as a work experience report, or a colloquium for group work with an additional, individual examination)*

Module Name	Abbreviation
Programming Basics	**ProgB**

Responsible	Lecturer / Examination Type
Prof. Dr. Silke Lechner-Greite	See overview page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Wirtschaftsinformatik Bachelor: compulsory 1st semester Applied Artificial Intelligence Bachelor: compulsory 1st semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminar-based teaching	4 SWS seminar-based teaching 2 SWS exercises	7 ECTS
Workload	Thereof Contact hours	Thereof Independent study
210 h	90 h	120 h

Prerequisites
Compulsory
none
Recommended
none
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies

Technical skills:

- Students will be able to explain the logic of programming and program development.
- Students will be capable of illustrating and applying basic programming concepts of object-oriented programming.
- Students will be proficient in applying the learned program development skills to practical programming problems.
- Students will be able to design, develop, test, and analyze small projects in an object-oriented manner while realizing a quality-oriented programming style.

Interdisciplinary skills:

- Students will learn to program in a modern software development environment.
- Students will acquire the ability to independently develop problem-specific solution approaches.
- Within the framework of more complex tasks and group work, students consolidate their abilities to transfer theoretically acquired basics into practice.

Short module description

Using Java as an example, students are introduced to the systematics of programming and the basic principles of program development. Basic programming concepts (e.g. software life cycle, programming rules, documentation, tests, control structures) are taught. Furthermore, students learn the basic elements of object-oriented programming (e.g. classes, objects, packages, exceptions). Special emphasis is placed on developing a good programming style that is largely independent of the programming language. The lecture is accompanied by exercises on modern PCs with a current development environment.

Agenda

1. Introduction (Software life cycle, overview of programming languages, programming tools, programming rules).
2. Basic language concepts (data types, variables and assignments, expressions and operators)
3. Control structures (instruction sequence, conditional statement and branching, control structures and loops)
4. Arrays (one-dimensional arrays, multi-dimensional arrays, Useful helper methods, Extended for loop)
5. Characters and strings (operations with characters, encoding of characters, Java library methods for characters, string literals, special features of the class String, library methods for strings, class StringBuilder)
6. Object-orientated Programming (comparison of selected programming paradigms, core principles of object-orientation programming, definition of terms and characteristics of objects)
7. Classes (definition and characteristics of classes, programming classes in Java)
8. Packages (idea, handling packages, access protection, archive files)
9. Exceptions (motivation, realization approaches and implementation aspects of exceptions in Java)
10. Java Unit Testing (based on the JUnit Framework)
11. I/O - read and write files

Reading List & Media

Recommended

Englisch Reading:

Sierra, Kathy; Bates, Bert: Head First Java, 3rd Edition, O'Reilly Media, Inc, 2021. ISBN: 978-1491910771

Liang, Y. Daniel: Introduction to Java Programming, Comprehensive Version, 12th Edition, Pearson, 2019, ISBN: 978-0136520238

German Reading:

Ullenboom, Christian: *Java ist auch eine Insel*. Rheinwerk Computing, aktualisierte Auflage von 2020, ISBN: 978-3836277372, Online Version: http://openbook.rheinwerk-verlag.de/javainsel/

Habelitz, Hans-Peter: *Programmieren lernen mit Java*. Rheinwerk Computing; 5. Edition 2017, ISBN: 978-3836256056

Schiedermeier, Rheinhard: *Programmieren mit Java*. Pearson Studium, 2. Auflage 2010, ISBN: 978-3868940312.

Additionally recommended
Java Language and Virtual Machine Specifications: https://docs.oracle.com/javase/specs/ Wikibooks *Java Programming*: https://en.wikibooks.org/wiki/Java_Programming
Media, teaching material
Presentations, practical exercises, project work, hands-on coding Presentation with digital projector, blackboard, live exercise/programming, e-learning platform, online quizzes, script/slides, practical exercises, modern software development environment.

Module Name	Abbreviation
Project Management	**PM**

Responsible	Lecturer / Examination Type
Prof. Dr. Claudia Förster	See overview page 1 / written exam 60-120 min

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence B. Sc.: compulsory 4th semester		
Duration	Frequency	Language
1 semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl) excercises (ex)	4 hours/week sl 2 hours/week ex.	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The students can explain elementary project management terms and common approaches of modern project management. Students will be able to describe important project management tasks and clarify processes and interrelationships. Students will be able to apply selected methods and techniques of project management. Students will be able to analyze project situations and derive recommendations for action. Furthermore, the students' personality development will be promoted, especially the ability for critical self-reflection as well as social commitment.
Short module description
At the beginning of the course, an introduction to project management is given and important conceptual basics are explained. Subsequently, different types of projects are considered and different project management approaches are discussed. Afterwards, selected methods and techniques for typical project phases are presented, discussed and applied to concrete tasks and project situations.

Agenda

1. Introduction and basics of project management
   (Motivation, characteristic features of projects, definition of terms, overview of different project management approaches)
2. Classical project management
   (Characteristic features and selection of typical process models, selected methods and techniques for initialization, definition, planning, control and completion of projects as well as the processing of continuous tasks)
3. Agile project management
   (Agile manifesto and agile values, comparison with classic project management, Scrum, Kanban)
4. Hybrid project management
   (Definition of terms, various options for combining classic and agile process models, procedure for selection, integration and company-specific adaptation)

Reading List & Media

Recommended

Wysocki, R.K.: Effective Project Management: Traditional, Agile, Extreme, Hybrid, Wiley, 8. Edition, 2019

Kerzner H.: Project Management: A Systems Approach to Planning, Scheduling and Controlling, Wiley, 12. Edition, 2017

Sutherland, J.J.: Scrum: The Art of Doing Twice the Work in Half the Time, Random House Business, 1. Edition, 2015

Anderson, D.J.: Kanban: Successful Evolutionary Change for Your Technology Business, Blue Hole Press, Illustrated Edition, 2010

Additionally recommended

Project Management Institute: A Guide to the Project Management of Knowledge (Pmbok Guide), Sixth Edition, 2017

Project Management Institute: Agile Practice Guide, Illustrated Edition, 2017

Media, teaching material

Presentations, practical exercises, project work, blended learning

Module Name	Abbreviation
Software Engineering (AAI)	**SE**

Responsible	Lecturer / Examination Type
Prof. Dr. Ewald Jarz	see overview from page 1 / written exam 60-120 Min.

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Informatik Bachelor: compulsory 4th semester Wirtschaftsinformatik Bachelor: compulsory 4th semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Contact hours per week	Credit Points
seminaristic instruction (si)	2 chw si 2 chw laboratory course	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended
Programming Basics, Object-oriented Programming, Database Systems

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The students know the goals, methods, techniques and procedures of software engineering. You understand the individual steps of the software development process and master the most important methods in theory and practice. In addition to subject-specific skills, project management skills and the ability to work in a team should be particularly strengthened. The students can transfer abstract concepts to use cases.
Short module description
This module provides an introduction to basic design principles of systems, including modelling principles and the use of tools, and design patterns. It also looks into different software processes, and introduces software testing. Regarding software project management, topics like risk management, quality assurances are covered.

Agenda
1. Introduction & project initiation Introduction, reasons for the failure of IT projects, software engineering, problems with software development projects, client / contractor, project initiation, offer / contract

2. Procedure models
   Effort estimate, criticality, software lifecycle, process models, phase model, waterfall model, spiral model, V-model
3. Heavy weight process models
   V-Modell XT, Unified Process, Frameworks (ITIL, COBIT, ISO20000)
4. Lightweight process models
   Agile models, eXtreme programming, agile practices, SCRUM
5. Requirements engineering
   MVP, survey methods, requirements analysis, functional / non-functional requirements, requirement specification, requirement specification / functional specification, requirement evaluation
6. Function-oriented system models
   Types of system models, modeling bases, flowcharts, structured charts, decision tables, pseudo-code, eEPC
7. Data-oriented models
   3 schema model, information modeling, ER diagram, data dictionary, data flow diagram
8. Object-oriented structural models
   UML class diagram, UML object diagram, UML distribution diagram, UML component diagram, UML composition structure diagram, UML package diagram
9. Object-oriented behavior models
   UML use case diagram, UML state diagram, UML activity diagram
10. Object-oriented interaction models
    UML sequence diagram, UML communication diagram, UML time diagram, UML interaction overview diagram, BPMN
11. Design
    Software architecture, principles of architecture design, architecture patterns, design patterns, domain modeling, usability engineering / prototyping, persona models
12. Implementation
    Technology stack, IDE, system landscape, guidelines for coding, DevOps, configuration management
13. Testing, debugging
    Software test, test case specification, test procedure, test controlling, types of testing
14. Documentation & risk management
    Areas of documentation, documentation organization, documentation for agile procedures, risk definition, risk management

Reading List & Media

Recommended

Sommerville, Ian: Software Engineering.- Pearson, 2021.

Jacobson, Ivar; Lawson, Harold; Ng Pan-Wei: The Essentials of Modern Software Engineering.- ACM Books, 2019

OMG (Editor): OMG Unified Modeling Language Version 2.5.1.- OMG, 2017

Additionally recommended

Bourque, Pierre; Fairley , Richard: Guide to the Software Engineering Body of Knowledge (SWEBOK(R)): Version IEEE Computer Society Press, 2014

Dick, Jeremy; Hull, Elizabeth; Jackson, Ken: Requirements Engineering.- Springer, 2017

Unhelkar, Bhuvan: Software Engineering with UML.- Auerbach Publications, 2017

Ludewig, Jochen; Lichter, Horst: Software Engineering. dpunkt , 2013

Media, teaching material

Presentation with projector and blackboard, review questions with exercise examples, exercise with case studies to deepen the subject

Module Name	Abbreviation
Speech Recognition and Sequence Learning	**SRSL**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	Check overview from page 1 / written exam 60-120 or oral exam 15-45-

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: compulsory, 6th semester		
Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	6 hours/week sl	7 ECTS
Workload	Thereof Contact hours	Thereof Independent study
210 h	210 h	210 h

Prerequisites
Compulsory
At least 80 CP
Recommended
Neural Networks and Deep Learning
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
The students know and understand the theoretical and algorithmic basics of processing spoken language. They know procedures for speech recognition (ASR) as well as for speech generation (speech synthesis). In addition, the students have the theoretical and practical knowledge of typical procedures and algorithms in the field of language processing (Natural Language Processing, NLP). They have experience in the application or implementation of speech recognition, processing and generation. They can analyse subject-specific problems in a scientifically sound manner, understand complex interrelationships and implement them in a targeted manner by selecting suitable models.
Short module description
Speech processing covers a broad spectrum. Today's assistance systems, e.g. Amazon Alexa or Siri, accept voice commands, convert them into text, understand this text and respond to it with a corresponding output. What many users take for granted in this process involves a range of technical and algorithmic systems for speech processing. This module covers speech processing to recognise speech (Speech Recognition), process speech (NLP) and also reproduce speech (Speech Synthesis). Therefore, sequence learning is taught a foundation for a various set of applications.

Students are taught the theoretical and algorithmic foundations of speech recognition, processing and generation, as well as sequence learning. Different approaches are presented and dealt with in the sub-areas. Advantages and disadvantages of the respective approaches are worked out and implemented programmatically using concrete examples.

Agenda

1. Introduction and overview
2. Basics of machine language processing
3. Natural language processing
    a. TF-IDF, Word2Vec, Bag of Words
    b. N-Grams
    c. Entity Detection, Sentiment Analysis and Key Word Extraction
4. Deep Learning methods for Speech Recognition
    a. Hidden Markov Models (HMM)
    b. Acoustic models (phonemes, ...)
    c. Language models (e.g. with n-grams, ...)
5. Sequence Learning
    a. Recurrent neural networks
    b. LSTMs and GRUs
    c. Sequence-to-sequence learning
6. Speech synthesis
7. Practical applications of machine speech processing
    a. Assistance systems
    b. Chatbots
    c. Real-time translations

Reading List & Media

Recommended

Steven Bird, Ewan Klein, and Edward Loper: *Natural Language Processing with Python – Analyzing Text with the Natural Language Toolkit* (http://www.nltk.org/book/)

Perkins, J.: Python 3 Text Processing with NLTK 3 Cookbook. Packt Publishing Ltd., 2014

D. and Martin, J.: *Speech and Language Processing*, (online verfügbar: http://web.stanford.edu/~jurafsky/slp3/), 2019

Dong Yu, Li Deng, *Automatic Speech Recognition: A Deep Learning Approach*, Springer, 2014

Additionally recommended

Li Deng, Yang Liu: *Deep Learning in Natural Language Processing*, Springer, 2018.

Goodfellow, I., Bengio, Y., Courville, A.: *Deep Learning*, MIT Press, 2017 (online verfügbar: http://www.deeplearningbook.org/).

Media, teaching material

Presentations, exercises

Module Name	Abbreviation
Stochastics	**Stoch**

Responsible	Lecturer / Examination Type
Prof. Dr. André Herzwurm	Check overview from page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
Applied Artificial Intelligence Bachelor: 3rd semester		
Duration	Frequency	Language
1 semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture and excersises	3 hours/week si, 1 hour/week exercises	5 ECTS
Workload	Thereof Contact hours	
150 h	60 h	

Prerequisites
Compulsory
At least 30 CP
Recommended
Mathematical fundamentals: Analysis 1, Analysis 2, Linear Algebra
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Identify stochastic aspects in applied processes and issues. Identify necessary data structures for statistical modelling. Acquire an overview of basic descriptive and explorative methods of statistical data analysis and know the limits of these methods. Gain the basics of probability theory and the fundamental principles of applied inductive statistical methods. Be able to describe mathematically stochastic systems, be able to apply statistical methods and be able to interpret critically results of a statistical analysis. Knowledge of applying statistical methods using current statistics software (R).
Short module description
Introduction to fundamental probability calculus and statistical methods with applications to statistical data analysis, statistical decision theory and statistical modelling.

Agenda
1. Descriptive and explorative statistics: data analysis, statistical sample, scales of measurement, measures of location, variability and correlation, graphical methods 2. Probability theory: elements of a probability space, random variable, independence, expected values, specific distributions, laws of large numbers 3. Inductive statistics: point estimation, interval estimation and statistical tests

4. Introduction to the linear model: Applied linear regression analysis
5. Statistical software: R

Reading List & Media
Recommended
Karr, A.F.: Probability. Springer (1993). Ross, S.M.: Introduction to Probability and Statistics for engineers and scientists. 4th edition, Academic Press (2009). Tijms, H.: Basic Probability: What Every Math Student Should Know. World Scientific (2019). Venables, W.N.: An Introduction to R, http://www.cran.r-project.org/doc/manuals/R-intro.pdf.
Additionally recommended
Billingsley, P.: Probability and Measure. Anniversary Edition, Wiley Series in Probability (2012). Fox, J. and Weisberg, S.: An R Companion to Applied Regression. 2nd edition, Sage Publications (2011). Gareth, J., Witten, D., Hastie, T. and Tibshirani, R.: An Introduction to Statistical Learning. Springer Texts in Statistics (2015). Tukey, J.: Exploratory Data Analysis, Addison-Wesley Reading Massachusetts (1977).
Media, teaching material
Lecture notes, exercise problem descriptions and solutions, R programs

Module Name	Abbreviation
Supervised Learning	**SVL**

Responsible	Lecturer / Examination Type
Prof. Dr. Johannes Jurgovsky	Check overview from page 1 / written exam 60-120 or oral exam 15-45

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: compulsory, 3rd semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic instruction (si)	4 hours/week si	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150 h	60 h	90 h

Prerequisites
Compulsory
At least 30 CP
Recommended
none
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know and understand the theoretical and algorithmic foundations of supervised machine learning. They learn to analyze difficult subject-specific problems in a scientifically sound manner. Students understand the characteristics of several commonly used supervised learning algorithms and acquire an overview of the algorithms' commonalities and differences within the supervised learning landscape. Students are empowered to select suitable algorithms for specific problems and enabled to implement the algorithms in software. They can evaluate classification performance and discuss ethical and social implications of their work.
Short module description
Students acquire the theoretical and algorithmic foundations of supervised machine learning: (statistical) preprocessing, classification, regression, and the tools for scientific experimentation.

Agenda
1. Introduction and Overview 2. Nearest Neighbor Learning 3. Linear and Polynomial Regression 4. Logistic Regression 5. Naive Bayes 6. Decision Trees 7. Support Vector Machines 8. Neural Networks 9. Ensemble Learning 10. Classifier Evaluation 11. Feature Normalization, Transformation & Selection

Reading List & Media
Recommended
Beyerer, J., Richter, M., Nagel, M.: *Pattern Recognition: Introduction, Features, Classifiers and Principles*, De Gruyter 2017. Bishop, Ch.: *Pattern Recognition and Machine Learning*, Springer 2006. Duda, R.O., Hart, P.E.: *Pattern Classification*, John Wiley & Sons, 2. Auflage, 2000.
Additionally recommended
Niemann, H.: *Klassifikation von Mustern*. 2. überarbeitete Auflage, 2003. http://www5.informatik.uni-erlangen.de/fileadmin/Persons/NiemannHeinrich/klassifikation-von-mustern/m00links.html Han J., Kamber M.: *Data Mining*. Morgan Kaufmann, 2011.
Media, teaching material
Presentations, exercises

Module Name	Abbreviation
Theoretical Computer Science	**TCS**

Responsible	Lecturer / Examination Type
Prof. Dr. Jochen Schmidt	Check overview from page 1 / written exam 60-120

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester
AAI-B: compulsory, 2nd semester INF-B: compulsory, 2nd semester

Duration	Frequency	Language
1 Semester	summer semester	English
Teaching methods	**Hours per week**	**Credit Points**
seminaristic lecture	4 hours/week si	5 ECTS
Workload	**Thereof Contact hours**	**Thereof Independent study**
150 h	60 h	90 h

Prerequisites
Compulsory
none
Recommended
Computer Science Fundamentals
Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know and understand the fundamentals and practical relevance of theoretical computer science, especially in the areas of automata theory, formal languages, computability and complexity. The ability to think analytically and logically and to analyze technical problems is fostered.
Short module description

Agenda

1. Basic concepts of automata theory
   finite automata, basement automata
   Turing machines

2. Introduction to the theory of formal languages
   definition of formal languages, Chomsky hierarchy
   pumping theorem
   analysis of words, CYK parser

3. Basics of computability
   Church-Turing thesis
   Halting problem
   LOOP/WHILE/GOTO computability
   introduction to primitive recursive and μ-recursive functions

4. Complexity
   order of complexity (O-notation)
   complexity classes P/NP, NP-completeness
   divide and conquer

5. Probabilistic algorithms
   random numbers
   Monte Carlo methods
   probabilistic prime number test

Reading List & Media

Recommended

H. Ernst, J. Schmidt und G. Beneken. *Grundkurs Informatik*. Springer Vieweg, 7. Aufl. 2020.

J. Schmidt. *Grundkurs Informatik – Das Übungsbuch: 148 Aufgaben mit Lösungen*. Springer Vieweg, 2. Aufl. 2020.

J. Hopcroft, R. Motwani und J. Ullmann. *Introduction to Automata Theory, Languages, and Computation*. Pearson Education Limited, 2013.

D.W. Hoffmann. *Theoretische Informatik*. Hanser, 4. Aufl. 2018.

Additionally recommended

U. Schöning. *Theoretische Informatik - kurz gefasst.* Spektrum Akad. Verlag, 5. Aufl. 2008.

A. Aho, M. Lam und R. Sethi. *Compilers.* Addison-Wesley Longman, 2013.

K. Erk und L. Priese. *Theoretische Informatik. Eine umfassende Einführung*. Springer, 3. Aufl. 2009.

D.E. Knuth. *The Art of Computer Programming*. Addison-Wesley, 3. Ed. 1997.

W.H. Press, et al. *Numerical Recipes 3rd Edition: The Art of Scientific Computing.* Cambridge University Press, 2007.

R. Sedgewick. *Algorithms*. Addison-Wesley, 4. Ed. 2011.

Media, teaching material

Presentations, exercises

Module Name	Abbreviation
Unsupervised and Reinforcement Learning	**URL**

Responsible	Lecturer / Examination Type
Prof. Dr. Marcel Tilly	Check overview from page 1 / written exam 60-120

Allocation to the curriculum (Compulsory, FWPM Subject-specific compulsory Module) / Study Semester		
AAI-B: compulsory, 3rd semester		
Duration	Frequency	Language
1 Semester	winter semester	English
Teaching methods	Hours per week	Credit Points
seminaristic lecture (sl)	4 hours/week sl	5 ECTS
Workload	Thereof Contact hours	Thereof Independent study
150h	90h	60h

Prerequisites
Compulsory
At least 30 CP
Recommended
Introduction to AI (Part I & II), Analysis (I+II)

Learning Outcomes & Content
Knowledge / Skills / Abilitites / Competencies
Students know fundamentals and details of unsupervised and reinforcement learning in contrast to supervised learning. Students know various techniques in unsupervised and reinforcement learning. Students can use and implement algorithms for unsupervised and reinforcement learning. Students can decide which approach can be applied to which problem. Students can analyses and measure the quality of various models for unsupervised and reinforcement learning.
Short module description
Besides supervised learning you can also find unsupervised and reinforcement learning in the machine learning world. Unsupervised learning is a machine learning technique in which the users do not need to supervise the model. Instead, it allows the model to work on its own to discover patterns and information that was previously undetected. It mainly deals with the unlabeled data Reinforcement learning is the training of machine learning models to make a sequence of decisions. An agent learns to achieve a goal in an uncertain, potentially complex environment. In reinforcement learning, an artificial intelligence faces a game-like situation. The computer employs trial and error to come up with a solution to the problem. To get the machine to do what

the programmer wants, the artificial intelligence gets either rewards or penalties for the actions it performs. Its goal is to maximize the total reward.

The students will learn both the mathematical background and the programming environments for unsupervised and reinforcement learning. The students gain programming experience in openAI and other platforms.

Various scenarios and problems will be discussed and analyzed so that students will learn when to use which approach.

Agenda

1. Introduction into unsupervised and reinforcement learning
2. Concepts of Unsupervised Learning
    a. Clustering
    b. Anomaly Detection
    c. Latent variable models
    d. Hierarchical Aggregation
    e. Self-Organizing Feature Maps
3. Concepts of Reinforcement Learning (RL)
    a. Introduction into Value-, Policy-, Model -based Learning
    b. Model-based vs. Model-free
    c. Q-Learning
    d. SARSA
4. Deep Reinforcement-Learning
5. Applications of RL
    a. Scenarios with OpenAI Gym
    b. Projekt Malmö for Minecraft in Python/C#
6. Concepts of Genetic Algorithms

Reading List & Media

Recommended

Richard S. Sutton , Andrew G. Barto: *Reinforcement Learning: An Introduction (Adaptive Computation and Machine Learning)* (Englisch)

Stuart Russell, Peter Norvig: *Artificial Intelligence: A Modern Approach*, Global Edition (Englisch)

Maxim Lapan: *Deep Reinforcement Learning Hands-On: Apply modern RL methods, with deep Q-networks, value iteration, policy gradients, TRPO, AlphaGo Zero and more* (English Edition)

Patel, A: *Hands-On Unsupervised Learning Using Python*, OReilly (2019)

Buontempo, F.: *Genetic Algorithms and Machine Learning for Programmers: Create AI Models and Evolve*, Pragmatic Programmers, 2019

Additionally recommended

Praveen Palanisamy: *Hands-On Intelligent Agents with OpenAI Gym: Your guide to developing AI agents using deep reinforcement learning,*

Media, teaching material

Presentations, exercises