Technische Hochschule Ingolstadt

Module Handbook

Computer Science and Artificial Intelligence (SPO WS 21/22)

Bachelor

Faculty of Computer Science

Study regulation: WS 21/22

As per: 2024-02-21

Table of Contents

1 Outline

Name of the Degree Program	Computer Science and Artificial Intelligence (Bachelor)
Type of study & Degree	undergraduate, full time, B.Sc. (Bachelor of Science)
Initial start date	Winter semester 2021/22, annual cycle
Number of semesters	7 semesters, 210 credit points (ECTS), 142 semester hours
Position of the internship semester	5th semester
Place of study	THI, Campus Ingolstadt
Language of instruction	English
Cooperation	none; Dual studying is not possible
Admission requirements	University entrance qualification
Capacity	50 students annually
Head of Degree Program	Prof. Dr. Hans-Michael Windisch E-Mail: Hans-Michael.Windisch@thi.de Phone: +49 (0) 841 / 9348-2480
Academic Advisor	Prof. Dr. Wolf-Dieter Tiedemann E-Mail: wolf-dieter.tiedemann@thi.de Phone: +49 (0) 841 / 9348-2310
Internship Commissioner	Prof. Dr. Bernd Hafenrichter E-Mail: bernd.hafenrichter@thi.de Phone: +49 (0) 841 / 9348-2522

2 Introduction

The text describes the current curriculum of the Bachelor's degree program "Computer Science and Artificial Intelligence".

In particular, it points out the study objectives and module contents of all compulsory modules, the subject-scientific elective modules and the internship-accompanying courses of the program as well as the semester hours per module and study semester.

In case of ambiguity, the superordinate study and examination regulations take precedence.

2.1 Background

For years, it has been pointed out again and again that Germany, just like the rest of the world, is lacking more computer scientists than ever before: the gap is growing every year. The digital transformation of the working world as well as of private life through technologies such as the Internet of Everything, Artificial Intelligence (AI) and Big Data Analytics based on increasingly powerful hardware and connectivity solutions is the driver for this demand. In contrast, the number of Computer Science graduates is growing comparatively slowly.

In addition to the German-language programs offered by the THI in various Computer Science disciplines, the English-language program "Computer Science and Artificial Intelligence" is intended to inspire students to pursue a career as Computer Science and AI specialist. By using English as the language of instruction, the catchment area for applicants can be extended worldwide. On the one hand, this gives the region's labor market access to well-educated graduates who would otherwise have been difficult to attract, and on the other hand, it supports the THI's internationalization strategy, which, in addition to increasing the international visibility of the THI, also aims to promote exchange and cooperation in teaching and research through international working groups (→ internationalization@home).

2.2 Study Objectives

The objective of the Bachelor's degree program "Computer Science and Artificial Intelligence" is to provide students a technical expertise in the field of Computer Science, with a special focus on AI. This is achieved by an application-oriented teaching based on scientific results and methods. Graduates are suitably qualified for responsible professional positions in globally active enterprises and organizations in this field. In addition to the transfer of knowledge, understanding and practical skills, the development of personal skills is another important goal.

Graduates know the most important concepts, methods and techniques of Computer Science and can think in abstract models, assess the possibilities and limitations of algorithmic procedures and develop adequate computing solutions for complex application problems. They have a fundamental understanding of the most important AI technologies and can introduce, integrate, customize or develop AI systems in companies to provide digital solutions that mimic the aspects of human cognition or decision-making and adapt to changing conditions. The graduates are aware of their responsibility for the social and societal impact of their work and respect the diversity of people. To keep up with the rapidly progressing development of computer science, they consider themselves as lifelong learners and researchers.

The Bachelor's degree offers the basis for further scientific qualification in a consecutive Master's degree program.

2.3 Target Group

The Bachelor's degree program "Computer Science and Artificial Intelligence" is aimed at applicants who:

- are interested in information processing and are aiming for a job or a research career in the field of Computer Science, in particular with a focus on Artificial Intelligence,
- have a thorough understanding of basic Mathematics, a good ability to abstract and the ability to think logically,
- (as an international applicant) would like to pursue a later career in Germany or would like to support German companies or organizations abroad, or (as a German applicant) intend to lay the foundation for an international career,
- want to help shape the digital future in a globalized world.

2.4 Admission Requirements

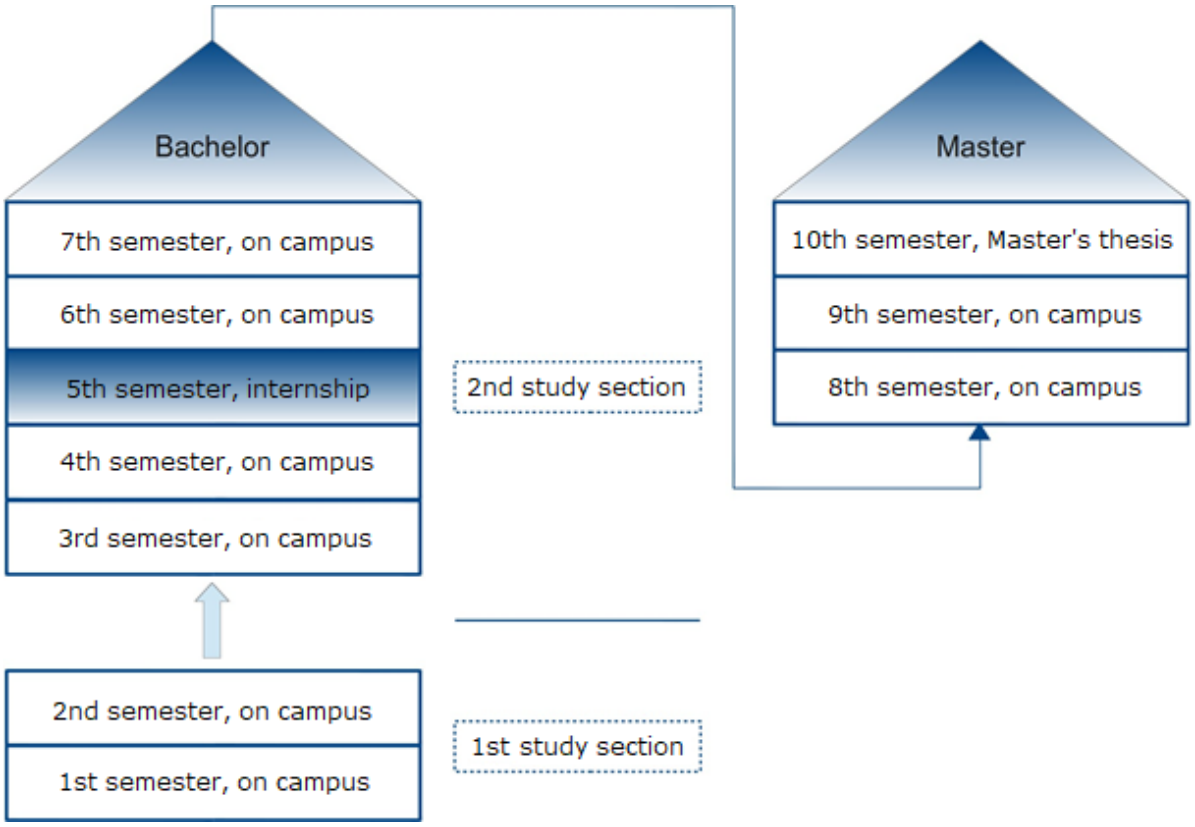
For admission to the Bachelor's degree program "Computer Science and Artificial Intelligence", the general university entrance requirements for studying at Bavarian Universities of Applied Sciences must be met. As a rule, these are either the general or the subject-restricted university entrance qualification. The detailed regulations can be found in the Ordinance on Qualification for Studies at Universities of the Free State of Bavaria (QualV).

International applicants whose certificates are not issued in German language and according to the German grading scheme must submit their school and university certificates to uni-assist in order to determine their eligibility for studying at THI. Uni-assist will prepare a preliminary review documentation (VPD) which must be submitted together with an application to THI. The uni-assist website also provides access to a database that allows an initial assessment of whether the university entrance qualification obtained abroad qualifies the international student for studying in Germany.

Since winter semester 2022/23, the Bachelor's degree program "Computer Science and Artificial Intelligence" has been subject to admission restrictions. The THI determines the admission figures annually by statute.

2.5 Structure and Duration of the Study Program

The regular period of study of the Bachelor's degree program “Computer Science and Artificial Intelligence” comprises seven semesters. The study program is divided into two study sections.



The first study section consists of two in-classroom semesters. The second study section includes four in-classroom semesters and a full internship semester, which is usually the 5th semester.

It is possible to continue the Bachelor’s degree program “Computer Science and Artificial Intelligence” directly with a suitable Master’s degree program, provided that its admission requirements are met.

2.6 Practical Study Semester (Internship Semester)

The practical study semester within the second study section covers a period of 20 weeks and is accompanied by courses. All students must pass the practical semester during their studies. The main part of the practical semester is an internship that is completed in a company in industry, small and medium-sized businesses or public administration.

Students choose their internship employer independently. If no student of the THI has ever done an internship with this internship employer before, the approval of the internship commissioner must be obtained in advance.

The internship is accompanied by two courses at the THI, one of which takes place before (Pre-internship Seminar) and the other after the internship (Post-internship Seminar).

2.7 Advancement Requirements

To ensure that the skills required for understanding the next stages of study are available, there are some advancement requirements. Failure to meet these requirements will result in a delay in study progress that should be used to re-work on the respective gaps. In order to keep the overall duration of studies within reasonable limits, there are also some deadlines to be observed.

The following list provides an overview of these requirements and deadlines[1]:

1. Only students who have earned at least 42 ECTS credit points from the modules of the first two semesters can enter the third semester.
2. Only students who have passed all examinations and performance certificates of the first study section, and who have acquired at least 20 ECTS credit points from the compulsory modules of the second study section can enter the practical semester.
3. Prerequisite for issuing a topic for the Bachelor's thesis is the successful completion of the internship semester.

The wording of the binding regulations can be found in the Study and Examination Regulations (SPO) of the program "Computer Science and Artificial Intelligence", in the Bavarian Examination Regulations Framework (RaPO), in the General Examination Regulations of the THI (APO) and in the Matriculation statutes of the THI under the following link: www.thi.de/en/university/university-profile/hochschulorganisation/legal-department.

[1] legally binding for advancement and admission requirements are only the Study and Examination Regulations

2.8 Academic Degree

After successfully passing all exams, THI awards graduates of the program “Computer Science and Artificial Intelligence” the academic degree:

Bachelor of Science (B.Sc.)

3 Curricular Structure

3.1 Structure of the First Study Section

The first study section comprises two in-classroom semesters.

Module	no.	Submodules	Breakdown by semester			
			1st sem	2nd sem	sem hrs/wk	CP
Programming 1	1.1	Programming 1	P		4	7
	1.2	Practical Course Programming 1	LN		2	
Introduction to Computer Science I	2.1	Introduction to Computer Science I	P		4	7
	2.2	Exercise Course Introduction to Computer Science I			2	
Mathematics 1	3.1	Mathematics 1	P		4	7
	3.2	Exercise Course Mathematics 1			2	
Probability and Statistics	4.1	Probability and Statistics	P		4	7
	4.2	Exercise Course Probability and Statistics			2	
Introductory Project	5	Introductory Project	LN		2	2
Programming 2	6.1	Programming 2		P	4	7
	6.2	Practical Course Programming 2		LN	2	
Introduction to Computer Science 2	7.1	Introduction to Computer Science 2		P	4	7
	7.2	Exercise Course Introduction to Computer Science 2			2	
Mathematics 2	8.1	Mathematics 2		P	4	7
	8.2	Exercise Course Mathematics 2			2	
Algorithms for AI 1	9.1	Algorithms for AI 1		P	4	7
	9.2	Practical Course Algorithms for AI 1		LN	2	
Scientific Research Methods	10	Scientific Research Methods		LN	2	2
Summe					**52**	**60**

Legend:

sem hrs/wk	semester hours per week
CP	credit points according to the European Credit Transfer System (ECTS)
P	written exam
LN	proof of achievement
Prj	project work and report
SP	seminar paper and presentation

For achievements that have to be completed in several parts or in modules with accompanying labs, further requirements may apply that are regulated in the appendix to the study and examination regulations (SPO).

3.2 Structure of the Second Study Section

3.2.1 In-classroom Semesters

Module	no.	Submodules	Breakdown by semester			
			3rd sem	4th sem	sem hrs/wk	CP
Software Engineering	11.1	Software Engineering	P		4	7
	11.2	Practical Course Software Engineering	LN		2	
Web Technologies	12.1	Web Technologies	P		4	7
	12.2	Practical Course Web Technologies	LN		2	
Optimization Algorithms	13	Optimization Algorithms	P		4	5
Algorithms for AI 2	14.1	Algorithms for AI 2	P		4	7
	14.2	Practical Course Algorithms for AI 2	LN		2	
Data Visualization and Data Analytics	15	Data Visualization and Data Analytics	P		4	5
Database Systems and Big Data Technologies	16.1	Database Systems and Big Data Technologies		P	4	7
	16.2	Practical Course Database Systems and Big Data Technologies		LN	2	
Spoken and Natural Language Understanding	17.1	Spoken and Natural Language Understanding		P	4	7
	17.2	Practical Course Spoken and Natural Language Understanding		LN	2	
Computer Vision	18.1	Computer Vision		P	4	7
	18.2	Practical Course Computer Vision		LN	2	
Algorithms for AI 3	19.1	Algorithms for AI 3		P	4	7
	19.2	Practical Course Algorithms for AI 3		LN	2	
Seminar	20	Seminar		SP	2	3
Summe					**52**	**62**

Legend:

sem hrs/wk	semester hours per week
CP	credit points according to the European Credit Transfer System (ECTS)
P	written exam
LN	proof of achievement
Prj	project work and report
SP	seminar paper and presentation

For achievements that have to be completed in several parts or in modules with accompanying labs, further requirements may apply that are regulated in the appendix to the study and examination regulations (SPO).

Module	No.	Submodules	Breakdown by semester			
			6th Sem.	7th sem	sem hrs/wk	CP
Cyber Security	21.1	Cyber Security	P		4	7
	21.2	Practical Course Cyber Security	LN		2	
Human-Computer Interaction and Explainable AI	22.1	Human-Computer Interaction and Explainable AI	P		4	7
	22.2	Practical Course Human-Computer Interaction and Explainable AI	LN		2	
Business Administration and Entrepreneurship	23	Business Administration and Entrepreneurship	LN		4	5
Project Management	24	Project Management	P		4	5
Project	25	Project	Prj		2	5
Ethics and Law	26	Ethics and Law		LN	4	5
Elective Module	27	Elective Module		LN	8	10
Bachelor's Thesis	28.1	Seminar Bachelor's Thesis		SP	2	3
	28.2	Bachelor's Thesis				12
Summe					**38**	**59**

3.2.2 Internship Semester

Module	No.	Submodules	Breakdown by semester		
			5th sem	sem hrs/wk	CP
Pre-Internship Seminar	29	Pre-Internship Seminar	LN	1	2
Internship	30	Internship	Prj		25
Post-Internship Seminar	31	Post-Internship Seminar	LN	1	2
Summe				**2**	**29**

Legend:

sem hrs/wk	semester hours per week
CP	credit points according to the European Credit Transfer System (ECTS)
P	written exam
LN	proof of achievement
Prj	project work and report
SP	seminar paper and presentation

For achievements that have to be completed in several parts or in modules with accompanying labs, further requirements may apply that are regulated in the appendix to the study and examination regulations (SPO).

3.2.3 Elective Modules

In the 7th semester, two subject-specific elective modules must be taken. Elective modules should allow students to select subject specializations according to their individual interests. A catalog of suitable elective modules is compiled each semester. Elective modules often deal with very specific topics and are offered by external lecturers from professional practice, whose availability may be limited.

Online registration in elective modules occurs at the end of each preceding semester. This registration is necessary to determine the number of participants. Elective modules can only be organized if a sufficient number of participants is reached.

4 Qualification Profile

Artificial Intelligence is a technological megatrend in all high-tech countries of this world. It is undisputed that Artificial intelligence is already changing the economy and people's everyday lives worldwide and will continue to do so in the coming years. This is underscored not least by the development of political strategies and goals in most high-tech countries, including the German government's national AI strategy and the high-tech agenda of the state of Bavaria. Accordingly, the demand for AI specialists is high, with the trend continuing to rise.

Artificial intelligence is a branch of Computer Science that deals with the automation or simulation of cognitive abilities. Accordingly, it is essential that graduates know the most important concepts, methods and techniques in Computer Science and are able to apply them adequately. In addition, they must have a basic understanding of the most important AI technologies in order to be able to plan, install or integrate, customize, develop or implement AI systems.

In order to demonstrate that graduates of the "Computer Science and Artificial Intelligence" program at THI receive a high-quality Computer Science education that meets European standards, the learning objectives of this program are compared to the learning outcomes expected as an educational basis for practicing a profession or for post-graduate studies according to the Euro-Inf Framework Standards and Accreditation Criteria for Informatics Programmes. These learning outcomes are arranged into the following six categories:

- Underlying Conceptual Basis for Computer Science and Artificial Intelligence
- Analysis
- Design and Implementation
- Economic, Legal, Social, Ethical and Environmental Context
- Computer Science and Artificial Intelligence Practice
- Other Professional Competences

The following section relates these competencies to the individual modules in the "Computer Science and Artificial Intelligence" degree program.

4.1 Competence Matrices of the Degree Program

4.1.1 Underlying Conceptual Basis for Computer Science and Artificial Intelligence

The learning outcomes in this category identify skills that are essential to achieve the learning outcomes in the other categories. Graduates should be able to:

(1) describe and explain the essential facts, concepts, theories and mathematical methods relevant to computing, computing equipment, computer communication and applications, especially those based on artificial intelligence methods,

(2) outline the characteristics of relevant modern hardware and software and their practical application in computer science and artificial intelligence,

(3) outline relevant historical and current developments in computer science and artificial intelligence and show insight into possible future trends and developments,

(4) apply and integrate knowledge and understanding of other computer science disciplines in support of solutions in computer science in general and artificial intelligence in particular,

(5) demonstrate an awareness of the fact that the development of computer science and artificial intelligence applications in other specialist areas requires in-depth domain knowledge.

Underlying Conceptual Basis for Computer Science and Artificial Intelligence	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Programming 1	Introduction to Computer Science 1	Mathematics 1	Probability and Statistics	Introductory Project	Programming 2	Introduction to Computer Science 2	Mathematics 2	Algorithms for AI 1	Scientific Research Methods	Software Engineering	Web Technologies	Optimization Algorithms	Algorithms for AI 2	Data Visualization and Data Analytics	Database Systems and Big Data Technologies	Spoken and Natural Language Understanding	Computer Vision	Algorithms for AI 3	Seminar	Cyber Security	Human-Computer Interaction and Explainable AI	Business Administration and Entrepreneurship	Project Management	Project	Ethics and Law	Elective Modules	Bachelor's Thesis	Pre-Internship Seminar	Internship (18 weeks)	Post-Internship Seminar
(1) essential facts, concepts, theories and mathematical methods	●	●	●	●		●	●	●	●		○	○	●	●	○	○	○	○	●	○	○	○		○	○		○				○
(2) characteristics of relevant modern hardware and software	○	●			○	●	●		●		○	●		●	●	●	●	●	●	●	●	●		○	●		○				
(3) relevant historical and current development in CS and AI	○	●				○	●		●		●	●	●	●	●	●	●	●	●	●	●	●			○		●	○		○	○
(4) understanding of other computer science disciplines			○	○				○		○	○		○		○		○	○				○	●	○		●	●			○	○
(5) awareness that app development requires domain knowledge									○	○	●		○	○	○	○	●	●	○	○	○	○			●		○	●		●	○

● / ○ / ○ large / medium / small contribution to the intended learning objective

4.1.2 Analysis

The “Analysis” category involves the application of computer science and artificial intelligence concepts and tools to the analysis of both problems and their solutions. Graduates should be able to:

(1) use a range of techniques to identify the requirements of real-world problems, analyze their complexity and assess the feasibility of their solution,

(2) describe a problem and its solution at varying levels of abstraction,

(3) select and use relevant analytic, modelling and simulation methods,

(4) choose appropriate solution patterns, algorithms and data structures,

(5) analyze the extent to which a computer science and/or AI system meets the criteria defined for its current use and future development.

Analysis	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Programming 1	Introduction to Computer Science 1	Mathematics 1	Probability and Statistics	Introductory Project	Programming 2	Introduction to Computer Science 2	Mathematics 2	Algorithms for AI 1	Scientific Research Methods	Software Engineering	Web Technologies	Optimization Algorithms	Algorithms for AI 2	Data Visualization and Data Analytics	Database Systems and Big Data Technologies	Spoken and Natural Language Understanding	Computer Vision	Algorithms for AI 3	Seminar	Cyber Security	Human-Computer Interaction and Explainable AI	Business Administration and Entrepreneurship	Project Management	Project	Ethics and Law	Elective Modules	Bachelor's Thesis	Pre-Internship Seminar	Internship (18 weeks)	Post-Internship Seminar
(1) identify requirements and complexity of real-world problems	◉	●	○	◉		◉	◉	○	◉	●	●	◉	◉	◉	●	●	◉	◉	◉	○	●	●			●	○	◉	●		●	○
(2) describe a problem/solution at varying levels of abstraction	●	●	◉	◉	○	●	●	◉	◉	○	●	◉	◉	◉	●	●	●	●	◉	◉	●	◉	◉	○	●		◉	●		◉	
(3) select/use relevant analytic, modelling and simulation methods		○	○	●			○	○	●	○	◉		○	●	○		◉	◉	●		○	◉			○		○			○	
(4) choose solution patterns, algorithms and data structures	●	●	◉	◉		●	●	◉	●	◉	●	●	●	●	●	●	●	●	●	◉	●	●	○	◉	●	◉	◉	●		●	○
(5) analyze if system meets criteria for use and future development	●	●			◉	●	●		●	○	●	●		●	●	●	●	●	●		●	●	●		●	◉	○	●		◉	

● / ◉ / ○ large / medium / small contribution to the intended learning objective

4.1.3 Design and Implementation

Learning outcomes of the "Design and Implementation" category include the ability to design and develop an economically viable computer-based intelligent information processing system that meets a specific need. Graduates should be able to:

(1) specify and design computer and network hardware and software which meet specified requirements,

(2) describe the phases involved in different life cycle models used for specifying, building, testing and commissioning new systems and for maintaining existing systems,

(3) select and apply appropriate process models, programming environments, and data management techniques for projects that involve both traditional and emerging application areas of computer science and AI,

(4) describe and explain the design of systems and interfaces for human-machine and machine-machine interaction,

(5) apply relevant practical and programming skills to the creation of computer-based intelligent information processing systems.

Design and Implementation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Programming 1	Introduction to Computer Science 1	Mathematics 1	Probability and Statistics	Introductory Project	Programming 2	Introduction to Computer Science 2	Mathematics 2	Algorithms for AI 1	Scientific Research Methods	Software Engineering	Web Technologies	Optimization Algorithms	Algorithms for AI 2	Data Visualization and Data Analytics	Database Systems and Big Data Technologies	Spoken and Natural Language Understanding	Computer Vision	Algorithms for AI 3	Seminar	Cyber Security	Human-Computer Interaction and Explainable AI	Business Administration and Entrepreneurship	Project Management	Project	Ethics and Law	Elective Modules	Bachelor's Thesis	Pre-Internship Seminar	Internship (18 weeks)	Post-Internship Seminar
(1) specify/design computer and network hardware and software	●	●	◉	◉		●	●	◉	●	○	●	●	●	●	●	●	●	●	●	○	●	●			●	○	●	●		●	
(2) describe life cycle phases to specify, build, test systems	◉					◉			○	○	●	◉	○	○			○	○	○			◉		●	●		○	●		◉	
(3) apply appropriate process models, IDEs and DMPs for applications	●	○				●	○		◉		●	●	◉	◉	●	●	◉	◉	◉		◉	◉		●			◉	●		●	○
(4) describe and explain HMI and M²I systems and solutions	◉				◉	◉	◉		○			●		○	●		●	●	○			●	◉		◉		◉	◉		◉	○
(5) apply practical & programming skills to the creation of systems	●	○			○	●	○		●		◉	●	◉	●	●	●	●	●	●		●	●			●		◉	●		●	

● / ◉ / ○ large / medium / small contribution to the intended learning objective

4.1.4 Economic, Legal, Social, Ethical and Environmental Context

Computing activities can have impacts on individuals, economy, society, and the environment. The "Economic, legal, social, ethical and environmental context" category identifies the skills that graduates need to perform their activities in accordance with various legal and ethical constraints and in compliance with professional codes of conduct. Graduates should be able to:

(1) demonstrate awareness of the need for a high level of professional and ethical conduct in computer science and AI,

(2) explain how commercial, industrial, economic and social contexts affect practice in computer science and artificial intelligence,

(3) identify relevant legal requirements governing activities in computer science and AI, including data protection, intellectual property rights, contracts, product safety and liability issues, personnel issues, health and safety,

(4) explain the importance of privacy and information security issues in relation to the design, development, maintenance, monitoring and use of computer-based intelligent information processing systems.

Economic, Legal, Social, Ethical and Environmental Context	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	Programming 1	Introduction to Computer Science 1	Mathematics 1	Probability and Statistics	Introductory Project	Programming 2	Introduction to Computer Science 2	Mathematics 2	Algorithms for AI 1	Scientific Research Methods	Software Engineering	Web Technologies	Optimization Algorithms	Algorithms for AI 2	Data Visualization and Data Analytics	Database Systems and Big Data Technologies	Spoken and Natural Language Understanding	Computer Vision	Algorithms for AI 3	Seminar	Cyber Security	Human-Computer Interaction and Explainable AI	Business Administration and Entrepreneurship	Project Management	Project	Ethics and Law	Elective Modules	Bachelor's Thesis	Pre-Internship Seminar	Internship (18 weeks)	Post-Internship Seminar
(1) awareness that highly professional & ethical conduct is needed					O					●										O	O		●	O	O	●		○	O	●	○
(2) explain how financial and social constraints affect practice										O	○										O		●	●	O	●		○	O	●	○
(3) identify legal requirements governing system performance										○	○										●		○			●		○		O	○
(4) explain the importance of privacy and information security																					●	O				●		○		○	○

● / O / ○ large / medium / small contribution to the intended learning objective

4.1.5 Computer Science and Artificial Intelligence Practice

This category identifies the practical skills that graduates should have demonstrated by applying computer science and AI skills to a variety of situations and use cases. Graduates should be able to:

(1) demonstrate an awareness of appropriate codes of practice and industry standards,

(2) describe and explain management techniques appropriate to the design, implementation, testing, deployment and maintenance of computer-based intelligent information processing systems, including project management, software configuration management, change management, etc.,

(3) undertake literature searches and reviews using databases and other sources of information,

(4) design and conduct appropriate practical investigations (e.g. to assess system performance), to interpret system response data and draw conclusions.

Computer Science and Artificial Intelligence Practice	1 Programming 1	2 Introduction to Computer Science 1	3 Mathematics 1	4 Probability and Statistics	5 Introductory Project	6 Programming 2	7 Introduction to Computer Science 2	8 Mathematics 2	9 Algorithms for AI 1	10 Scientific Research Methods	11 Software Engineering	12 Web Technologies	13 Optimization Algorithms	14 Algorithms for AI 2	15 Data Visualization and Data Analytics	16 Database Systems and Big Data Technologies	17 Spoken and Natural Language Understanding	18 Computer Vision	19 Algorithms for AI 3	20 Seminar	21 Cyber Security	22 Human-Computer Interaction and Explainable AI	23 Business Administration and Entrepreneurship	24 Project Management	25 Project	26 Ethics and Law	27 Elective Modules	28 Bachelor's Thesis	29 Pre-Internship Seminar	30 Internship (18 weeks)	31 Post-Internship Seminar
(1) demonstrate awareness of codes of practice and standards	○	○				○	○		○	◉	◉	○	○	○	○	○	○	○	○	○	◉	○		◉	◉			◉		●	◉
(2) describe and explain management techniques																							●	●	◉	◉				◉	
(3) undertake literature searches and reviews using databases etc.	○	○	○	○	●	○	○	○	○	●	○	○	○	○	○	○	○	○	○	●	○	○	○	○	◉	◉	○	●		◉	
(4) design and conduct practical investigations and draw conclusions	◉					◉						◉				◉								○	●			●		◉	●

● / ◉ / ○ large / medium / small contribution to the intended learning objective

4.1.6 Other Professional Competences

The professional competences listed in this category are essential for communicating information, ideas, problems and solutions. In addition to the so-called “soft skills”, this category also includes personal and social competences. Graduates should be able to:

(1) organize their work independently, show initiative and take personal responsibility,

(2) communicate effectively with diverse audiences both verbally and using a variety of communication media,

(3) plan self-learning and improve personal performance as a foundation for lifelong learning and ongoing professional development,

(4) identify different ways of team organization and the various roles within a team,

(5) participate effectively in professional team work.

Other Professional Competences	1 Programming 1	2 Introduction to Computer Science 1	3 Mathematics 1	4 Probability and Statistics	5 Introductory Project	6 Programming 2	7 Introduction to Computer Science 2	8 Mathematics 2	9 Algorithms for AI 1	10 Scientific Research Methods	11 Software Engineering	12 Web Technologies	13 Optimization Algorithms	14 Algorithms for AI 2	15 Data Visualization and Data Analytics	16 Database Systems and Big Data Technologies	17 Spoken and Natural Language Understanding	18 Computer Vision	19 Algorithms for AI 3	20 Seminar	21 Cyber Security	22 Human-Computer Interaction and Explainable AI	23 Business Administration and Entrepreneurship	24 Project Management	25 Project	26 Ethics and Law	27 Elective Modules	28 Bachelor's Thesis	29 Pre-Internship Seminar	30 Internship (18 weeks)	31 Post-Internship Seminar
(1) show self-organization, initiative and personal responsibility	○	○	○	○	●	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	●	○	○	●	◉	●	◉
(2) communicate effectively both verbally and through various media					●															●					●			●	●	●	●
(3) plan self-learning in preparation for lifelong learning	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	○	○	○	○	◉	○	○	●		●	
(4) identify different ways of team organization and the roles in it					◉																		◉	●	●				●	●	
(5) participate effectively in professional team work					◉																		○		●				◉	●	

● / ◉ / ○ large / medium / small contribution to the intended learning objective

4.2 THI Mission Statement

The learning outcomes of the "Computer Science and Artificial Intelligence" program comply with the Principles of teaching as they are formulated in THI's mission statement "Personalities for a future worth living" as follows:

- Our graduates are cosmopolitan and innovative personalities.

  The international composition of the study groups, with nationalities from all continents, promotes the idea of cosmopolitanism, namely that all people are part of a single world community. Their interest and commitment to modern computer science and artificial intelligence shows that students are open to innovation.

- Our teaching staff supports students in their professional and personal development.

  The seminar-based face-to-face teaching format and the accompaniment of most modules by separate exercise or practical courses enable the greatest possible degree of interaction between students and lecturers. Seminars and projects in which students work self-directed but are supervised by instructors develop students toward self-dependence.

- We foster a spirit of innovation and teach entrepreneurial thinking.

  From the evolution of hardware and software technology and AI to the concepts commonly used today, the students recognize the innovation steps of the past and which considerations led to them. By addressing the open research questions of today, they are encouraged to think innovatively themselves. Through the module "Entrepreneurship" and the option to acquire a corresponding certificate during their studies at THI's Center of Entrepreneurship, they are introduced to the idea of founding their own start-up company.

- In practical courses, laboratory work and projects, our students acquire applicable problem-solving skills.

  If only the compulsory modules of the program are considered (without the internship semester and the Bachelor's thesis), the share of instructed exercise courses, labs and projects already amounts to about 42% of all semester hours. The task assignments are often based on current topics from research projects that the instructors are conducting in parallel at the THI.

- Our students gain international experience during their studies and acquire foreign language and intercultural skills.

  Due to the international diversity of the students, an intercultural exchange occurs automatically during their studies. International students learn the German language in their everyday life (level A1 is compulsory upon entering the program), the language of instruction is English. THI's International Office supports interested students in studying abroad for a semester or doing the internship semester at a foreign company.

- Small groups and seminar-based teaching formats allow for individual exchange with our students.

  The aim is to have group sizes of 50-60 students per year. Exercises and practical courses are usually offered in two parallel classes with group sizes of 25-30 students, seminars and projects are laid out for group sizes of 15 students.

  All teaching staff offer regular office hours every week that students can use to discuss subject-related and non-subject-related questions individually.

  As part of the continuous improvement of teaching quality, a round table is held once a year with all students of a cohort, where students can give direct feedback on their studies to the program director.

- We support the diversity of our students and help them develop their talents and self-competences.

  By learning and working together, students experience to benefit from different strengths and ideas in the group and to respect each other. At the same time, they develop communication skills in dealing with each other, such as arguing comprehensibly and transforming an initial disagreement into a consensus. Approximately 50% of the semester hours are spent in courses that have active student participation as a central element, such as projects, seminars, exercises and practical courses.

  Interested students can also get involved as tutors or in supporting THI's various research projects, thus getting to know teaching from the other side or research from the inside.

4.3 Concept of Exams and Tests

According to the 2010 version of the common structural guidelines for the accreditation of study programs, "in order to reduce the examination load, modules are generally completed with only one exam, the result of which is included in the final certificate".

This means that for modules that also include practical components, the successful completion of tests on these components is considered an "admission requirement" for the single module exam.

Depending on the objective and type of the individual modules, different forms of examination are used for the module exams.

- Written examination (schrP)

  A written exam is particularly suitable for examining professional and methodical competence. It takes place within the examination period at the end of a semester. The processing period of usually 90 minutes is sufficient examine the entire scope of learning at random.

- Seminar paper (SA)

  This is a term paper with oral presentation. The submission of the term paper and the oral presentation can take place during the semester.

  The learning objectives focus on presentation and communication competences and include the self-dependent compilation of a scientific topic, the structuring of the content, the comprehensible presentation and argumentation, the selection and handling of suitable media and the appropriate arrangement of the written elaboration. Thus, self-competencies must be demonstrated such as self-motivation and planning, time management, organization, and cognitive load management.

- Project work (ProjA)

  A project work is a group work in which several students work on a common task in a team. Each student has to contribute individually to the common task. The group presents its results orally at the end of the semester and submits a joint project report.

  In addition to technical and methodical competence, social competences must be demonstrated, such as teamwork skills, critical thinking and self-reflection.

- Proof of performance (LN)

  This is a generic term for a number of exam and test forms.

  In the case of practical courses, this type of examination usually involves practical laboratory work or programming tasks. In the case of main modules, it can alternatively be a written exam, an oral exam, a term paper or a presentation. Details are described in the appendix to the study and examination regulations and in the study plan.

- Internship report (PrB)

This report serves to reflect personal experiences and knowledge gained during the internship. Furthermore, these experiences and knowledge should be related to knowledge from the ongoing studies. In addition, the internship report should demonstrate the ability to formulate a coherent, subject-related text in a precise, objective and linguistically correct manner.

- Bachelor's thesis (BA)

  With the Bachelor's thesis, the student provides evidence at the end of his or her studies that he or she is capable of self-dependently writing a scientific paper under the supervision of an instructor.

4.4 Possible Career Fields

Graduates of the program are primarily prepared for specialist and managerial tasks in the following areas:

- Software development, AI and Data Science applications development, Cloud-based application development, Web application development, Mobile App development
- IT/Software and AI consulting, training
- Project management of IT/Software and AI projects.

Graduates are hired in application areas wherever information is stored, processed and transmitted – nowadays this is across all industries, enterprises and organizations. The industry with the most job searches for Computer Science and AI is currently Technology, followed closely by Consulting, Life Sciences, Retail and Media.

5 Description of Modules

5.1 Compulsory Modules

Programming 1			
Module abbreviation:	CAI_Prog1	**SPO-No.:**	1
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Lausser, Ludwig Maximilian
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	1.1: Programming 1 (CAI_Prog1) 1.2: Practical Course Programming 1 (CAI_Prog1Pr)
Lecture types:	1.1: SU/Ü - integrated lecture and exercises 1.2: Pr - laboratory
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

1.1: schrP90 - written exam, 90 minutes (CAI_Prog1)
1.2: LN - participation without/with success (CAI_Prog1Pr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 1.2).

Students must successfully complete and submit at least 7 exercise sheets.

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The module is designed to teach students to program in Python in a practical manner using industry standard methods, tools and technologies. It not only teaches students the Python programming language but also

improves their algorithmic thinking and problem-solving capabilities so that they can write code that actually works and produces the desired functional results.

After completion of the module the students will be able to

- understand the programming basics (operations, control structures, data types, etc.).
- readily use the Python programming language.
- apply various data types and control structure.
- understand class inheritance and polymorphism.
- understand the object-oriented program design and development.
- understand and begin to implement code.

Content:

The following topics are covered:

- Introduction: foundations of algorithms and information processing
- Information representation: Data Types, variables and basic data structures
- Control structures: conditional execution, loops, lists and list processing
- Procedural abstraction: functions modules and packages
- Objects and classes
- Advanced topics: exceptions, events and event-driven programming

Literature:

- LAMBERT, Kenneth A. and Martin OSBORNE, 2019. *Fundamentals of Python: first programs*. S. edition. Boston, MA: Cengage. ISBN 1-337-56009-X, 978-1-337-56009-2

Additional remarks:

None

Introduction to Computer Science 1

Module abbreviation:	CAI_CS1	**SPO-No.:**	2
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Tiedemann, Wolf-Dieter
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	2.1: Introduction to Computer Science I (CAI_CS1) 2.2: Exercise Course Introduction to Computer Science I (CAI_CS1Ex)
Lecture types:	2.1: SU - integrated lecture 2.2: Ü - exercises
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

2.1: schrP90 - written exam, 90 minutes (CAI_CS1)
2.2: LN - without assessment (CAI_CS1Ex)

Requirements:
None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The objective of this course is to develop a basic understanding of how algorithms (sequences of machine-executable computational steps) are executed on computers (program-controlled information processing systems).

After successful participation, the students are able

- to explain the concept of an algorithm.
- to assess whether a problem is calculable, i.e. an algorithm can be formulated to solve it.
- to estimate the complexity of a given algorithm.
- to understand how an algorithm is processed on a computer.
- to describe the structure of a universal computer and how it works.
- to classify various advanced computer architecture concepts.

Content:

Algorithms

- Concept of algorithms, properties, forms of representation
- Computability
  - Turing computability
  - LOOP, WHILE, GOTO computability
  - Church-Turing thesis
- Decidability
  - Halting problem
  - RICE's theorem
- Complexity
  - O notation
  - Complexity classes P and NP

Computer architecture

- Binary representation of information
  - Natural, negative, fractional numbers
  - Machine instructions and programs
- Digital circuits
  - Logical elements, combinational circuits
  - Storage elements, registers, counters, sequential circuits
- Von Neumann architecture
- Advanced concepts in today's computer architectures
  - Caching
  - Multi-core architectures
  - Instruction pipelining
  - Graphics processing units

Literature:

- PATTERSON, David A. and John L. HENNESSY, 2021. *Computer organization and design: the hardware software interface*. S. edition. Cambridge, MA: Morgan Kaufmann. ISBN 978-0-12-820109-1
- STALLINGS, William, 2016. *Computer organization and architecture: designing for performance*. 10. edition. Hoboken, NJ [u.a.]: Pearson Education.
- AHO, Alfred V., John E. HOPCROFT and Jeffrey D. ULLMAN, 1995. *The design and analysis of computer algorithms*. [. edition. Reading, Mass. [u.a.]: Addison-Wesley. ISBN 0-201-00029-6
- SIPSER, Michael. *Introduction to the Theory of Computation*.

Additional remarks:

None

Mathematics 1

Module abbreviation:	CAI_Math1	**SPO-No.:**	3
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Roegner, Katherine
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	3.1: Mathematics 1 (CAI_Math1) 3.2: Exercise Course Mathematics 1 (CAI_Math1Ex)
Lecture types:	3.1: SU - lecture 3.2: Ü - exercises
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

3.1: schrP90 - written exam, 90 minutes (CAI_Math1)
3.2: LN - without assessment (CAI_Math1Ex)

Requirements:
No requirements. A solid understanding of school mathematics is beneficial.

Prerequisites according examination regulation:

None

Recommended prerequisites:

high school level algebra and geometry

Objectives:

After successful completion of this course, the student is able to

- state the basic facts in logic and apply results to appropriate examples.
- understand the structure of proofs and construct proofs in computer-science related problems (for example, mathematical induction).
- represent complex numbers in various forms in order to solve equations and inequalities.
- analyse limit processes to sequences (explicit and recursively defined).
- state, apply, and interpret formulas and theorems in differential calculus.
- develop Taylor polynomials and approximate the error using Lagrange remainders.
- develop infinite series and determine their radii and intervals of convergence.

- state and apply the definition of Riemann integrals, the fundamental theorem of calculus and the mean value theorem for integrals. Apply the basic integration techniques such as substitution and partial integration.

Content:

- Foundations of logic
- Methods of proof, especially mathematical induction
- Relations and functions
- Sequences and series, convergence
- Continuity
- Differentiation
- Integration

Literature:

- FRIEDMAN, Menahem, KANDEL, Abraham, 2011. *Calculus light* [online]. Berlin [u.a.]: Springer PDF e-Book. ISBN 978-3-642-17848-1, 978-3-642-17847-4. Available via: https://doi.org/10.1007/978-3-642-17848-1
- RAHMANI-ANDEBILI, Mehdi, 2021. *Calculus: Practice Problems, Methods, and Solutions* [online]. Cham: Springer International Publishing PDF e-Book. ISBN 978-3-030-64980-7. Available via: 10.1007/978-3-030-64980-7

Additional remarks:

None

Probability and Statistics

Module abbreviation:	CAI_PrSt	**SPO-No.:**	4
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Krüger, Max
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	4.1: Probability and Statistics (CAI_PrSt) 4.2: Exercise Course Probability and Statistics (CAI_PrStEx)
Lecture types:	4.1: SU - lecture (CAI_PrSt) 4.2: Ü - exercises (CAI_PrStEx)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

4.1: schrP90 - written exam, 90 minutes (CAI_PrSt)
4.2: LN - without assessment (CAI_PrStEx)

Requirements:
None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

After successfully completing the module the students ...

- Category Knowledge:
  ... have knowledge of important concepts, processes, and applications of applied statistics.
- Category Comprehension:
  ... understand the importance of statistics in the description and treatment of application problems.
- ... can explain important statistical procedures using examples and thereby understand the essential procedures.
- Category Application:
  ... independently solve typical statistical tasks.
- ... recognize statistical problems that arise when working on application problems and solve them with suitable methods.

- ... familiarize themselves with new statistical methods if necessary.
- Category Analysis:
  ... critically question statistical methods with regard to their applicability for existing problems and check the results for plausibility.
- Category Evaluation:
  ... interpret and assess the results in the application context.

After successful participation in the Probability and Statistics module, the students will be able to meet the stochastic requirements of the advanced subjects and are able to familiarize themselves with further procedures.

Content:

Descriptive Statistics:

- attributes, scales, and random samples
- tabular and graphical representations
- location and variability measures
- bivariate covariance and correlation
- linear and nonlinear regression

Probability Theory:

- random events and probability
- probability calculus and combinatorics
- Bayesian probability
- discrete random variables
- continuous random variables
- discrete probability distributions
- continuous probability distributions
- quantiles of probability distributions

Inferential Statistics:

- limit theorems and parameter estimation
- foundations of confidence intervals
- confidence-interval estimators
- foundations of test theory
- construction of parameter tests
- parameter tests
- independence and goodness-of-fit tests

Literature:

- NAVIDI, William, 2020. *Statistics for engineers and scientists*. f. edition. New York, NY: McGraw-Hill Education. ISBN 978-1-260-54788-7, 1-260-54788-4
- HAGHIGHI, Aliakbar Montazer and Indika Rathnathungalage WICKRAMASINGHE, 2021. *Probability, statistics, and stochastic processes for engineers and scientists*. F. edition. Boca Raton, FL: CRC Press. ISBN 978-0-8153-7590-6
- WEINBERG, Sharon Lawner, Daphna HAREL and Sarah Knapp ABRAMOWITZ, 2021. *Statistics using R: an integrative approach*. Cambridge: Cambridge University Press. ISBN 978-1-108-71914-8

Additional remarks:

None

Introductory Project

Module abbreviation:	CAI_IntroPrj	**SPO-No.:**	5
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	1
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	2 ECTS / 2 SWS
Workload:	Contact hours: 23 h Self-study: 27 h Total effort: 50 h
Subjects of the module:	Introductory Project (CAI_IntroPrj)
Lecture types:	Prj - Project
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN - participation without/with success (CAI_IntroPrj)

Requirements:
None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

The study group works together on a task from computer science. The aim is to get to know each other, to try out elementary work techniques, to learn how the necessary knowledge can be obtained from the various services of the THI library, to train one's own time management and to discuss technical issues.

Content:

The students work in groups on a chatbot that can answer questions about the CAI degree program and about studying at TH Ingolstadt in general. The results of each group are presented and discussed. In addition to an introduction to the library, the following workshops will also be held:

- Learning Strategies & Time Management
- Intercultural Competency

Literature:

Will be specified at the beginning

Additional remarks:
Attendance is compulsory during the entire event!

Programming 2

Module abbreviation:	CAI_Prog2	**SPO-No.:**	6
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	6.1: Programming 2 (CAI_Prog2) 6.2: Practical Course Programming 2 (CAI_Prog2Pr)
Lecture types:	6.1: SU - lecture (CAI_Prog2) 6.2: Pr - laboratory (CAI_Prog2Pr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

6.1: schrP90 - written exam, 90 minutes (CAI_Prog2)
6.2: LN - participation without/with success (CAI_Prog2Pr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 6.2).

Within the practical course, five tasks, which deal with essential topics of the lecture will be given. To pass the practical course, all five tasks must be completed successfully with respect to task deadlines.

Prerequisites according examination regulation:

None

Recommended prerequisites:

Python programming to the extent of Programming 1

Objectives:

Lecture: After successful participation students are able to:

- explain the basics of object-oriented programming.
- use basic abstract data structures for algorithmic problem solving.
- create an algorithmic solution for moderately difficult problems.
- formulate given and self-designed data structures and algorithms in Java.

Practical Course: Upon completion of the course students have practical knowledge in the application of essential Java programming concepts such as inheritance, interface, etc. They also gain initial experience with the JUNIT test framework and user interface programming with JavaFX.

Content:

- Basics of object-oriented programming; key terms: class, object, method, message, interface, inheritance, polymorphism, etc.
- Programming knowledge in Java (general OOP and in the Java language: sequence control, data types, class libraries, programme structure via class hierarchy, parameter transfer mechanisms, lifetime and usability of objects, work of the garbage collector)
- Object-oriented modelling (data encapsulation and access protection in classes, structuring inheritance hierarchies, use of class libraries: collections, streams, threads)
- Dynamic data structures: linked lists, hash tables, trees, streams
- Advanced language concepts: interface definition via interfaces, exception handling, parameterised classes (generics), lambda expressions
- Graphical user interfaces with JavaFX, handling asynchronous events
- Parallel programming with threads

Practical course:

As part of the practical course, a media player is developed in the Java programming language. The player is operated via a JavaFX-based user interface. The acceptance tests are carried out automatically using predefined JUNIT test classes. The classes to be created must provide certain interface functionalities in order to successfully pass the tests.

Literature:

- SHARAN, Kishori, DAVIS, Adam L., 2022. *Beginning Java 17 Fundamentals: Object-Oriented Programming in Java 17* [online]. Berkeley, CA: Apress PDF e-Book. ISBN 978-1-4842-7307-4. Available via: https://doi.org/10.1007/978-1-4842-7307-4
- STREIB, James T., SOMA, Takako, 2023. *Guide to Java - A Concise Introduction to Programming* [online]. PDF e-Book. ISBN 978-3-031-22842-1. Available via: https://doi.org/10.1007/978-3-031-22842-1

Additional remarks:

None

Introduction to Computer Science 2

Module abbreviation:	CAI_CS2	**SPO-No.:**	7
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Tiedemann, Wolf-Dieter
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	7.1: Introduction to Computer Science 2 (CAI_CS2) 7.2: Exercise Course Introduction to Computer Science 2 (CAI_CS2Ex)
Lecture types:	7.1: SU - lecture (CAI_CS2) 7.2: Ü - exercises (CAI_CS2Ex)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

7.1: schrP90 - written exam, 90 minutes (CAI_CS2)
7.2: LN - without assessment (CAI_CS2Ex)

Requirements:
None

Prerequisites according examination regulation:

None

Recommended prerequisites:

Successful participation in module "Introduction to Computer Science 1"

Objectives:

This course continues a course from the previous semester, which created a basic understanding of how computable algorithms are executed on computers.

The objective of this course is to convey how the operating system, as an additional software layer, manages all those components of a computer that were introduced in the previous course in such a way that they can be shared by one or more application programs that run simultaneously. A second objective is to convey how autonomous computers can communicate and interact with each other over fixed or mobile networks.

After successful participation, the students are able:

- to explain the tasks and functions of operating systems.
- to understand and use basic operating system concepts, assess corresponding implementations and possible problems.

- classify existing operating systems and assess future developments.

They are also able:

- to describe and classify the basic concepts of computer networks.
- to explain the tasks of communication layers in a reference model and to identify them in local area networks and in the Internet.
- to understand the most important communication protocols of the Internet and to describe their characteristics and limits.

Content:

The content of this course covers the following subject areas:

- Operating systems
  - Definition, evolution, tasks, basic concepts
  - Processes, scheduling, interprocess communication, synchronization, threads
  - Memory management
  - File management
  - I/O management
  - Architecture
- Computer networks
  - History, classification, layered architecture
  - Physical layer, transmission media, line coding
  - Data link layer, MAC sublayer, Ethernet, Wi-Fi
  - Network layer, routing, IP addresses, IP, ICMP
  - Transport layer, TCP, UDP, TLS
  - Application layer, DHCP, DNS, SMTP, POP3, HTTP

Literature:

- TANENBAUM, Andrew S. and Herbert BOS, 2015. *Modern operating systems*. 4. edition. Boston [u.a.]: Pearson. ISBN 978-1-292-06142-9, 1-292-06142-1
- STALLINGS, William, 2018. *Operating systems: internals and design principles*. N. edition. Harlow, Essex, England: Pearson. ISBN 1-292-21430-9, 978-1-292-21430-6
- SILBERSCHATZ, Abraham, Peter B. GALVIN and Greg GAGNE, 2019. *Operating system concepts*. [. edition. Hoboken, NJ: Wiley. ISBN 978-1-119-45408-3
- KUROSE, James F. and Keith W. ROSS, 2022. *Computer networking: a top-down approach*. E. edition. Harlow: Pearson. ISBN 978-1-292-40546-9, 1-292-40546-5
- TANENBAUM, Andrew S., David WETHERALL and Nick FEAMSTER, 2020. *Computer networks*. S. edition. Harlow, United Kingdom: Pearson Education Limited. ISBN 978-1-292-37401-7

Additional remarks:

None

Mathematics 2

Module abbreviation:	CAI_Math2	**SPO-No.:**	8
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Roegner, Katherine
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	8.1: Mathematics 2 (CAI_Math2) 8.2: Exercise Course Mathematics 2 (CAI_Math2Ex)
Lecture types:	8.1: SU - lecture 8.2: Ü - exercises
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

8.1: schrP90 - written exam, 90 minutes (CAI_Math2)
8.2: LN - without assessment (CAI_Math2Ex)

Requirements:
None

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

Upon completion of this course, the student is able to:

- manipulate matrices for specific purposes.
- identify vector spaces and linear mappings between vector spaces.
- apply theorems of linear algebra correctly.
- identify bases with special properties (orthonormal basis, diagonalizing basis, etc.).
- change between bases.

Content:

Upon completion of this course, the student is able to:

- perform standard matrix operations (addition, scalar multiplication, matrix multiplication, transposition, determinant)

- solve systems of linear equations efficiently, thereby identifying a particular solution and the kernel of the coefficient matrix
- decide whether a given structure represents a subspace of a vector space
- decide whether a mapping is linear, injective, surjective, bijective
- apply the dimension theorem in concrete situations
- determine coordinate mappings and representing matrices especially under a change of basis
- orthogonalize a given basis and deduce a QR-factorization of the associated matrix
- apply properties of the determinant in concrete situations
- understand the eigenvalue/eigenvector equation algebraically und graphically
- compute eigenvalues and eigenvectors
- decide on the diagonalizability of a given matrix

Literature:

- RILEY, Kenneth F., Michael P. HOBSON and Stephen J. BENCE, 2006. *Mathematical methods for physics and engineering*. 3. edition. Cambridge [u.a.]: Cambridge Univ. Press. ISBN 978-0-521-86153-3, 0-521-86153-5
- BIRD, John O., 2021. *Bird's basic engineering mathematics*. E. edition. London and New York: Routledge. ISBN 978-0-367-64367-6

Additional remarks:

None

Algorithms for AI 1

Module abbreviation:	CAI_AAI1	**SPO-No.:**	9
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Schön, Torsten
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	9.1: Algorithms for AI 1 (CAI_AAI1) 9.2: Practical Course Algorithms for AI 1 (CAI_AAI1Pr)
Lecture types:	9.1: SU/Ü - lecture with integrated exercises (CAI_AAI1) 9.2: Pr - laboratory (CAI_AAI1Pr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

9.1: schrP90 - written exam, 90 minutes (CAI_AAI1)
9.2: LN - participation without/with success (CAI_AAI1Pr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO No. 9.2). Students must successfully complete and submit at least 7 exercise sheets.

Prerequisites according examination regulation:

None

Recommended prerequisites:

None

Objectives:

In this learning module, basic algorithms of statistics-based artificial intelligence and their applications are explained. Students will learn the basic principles of machine learning using methods from supervised and unsupervised. The module will illustrate the fundamental ideas of learning patterns from data and how to use these models for predicting unseen data. Further, the theoretical knowledge will be applied to real world problems in practical exercises. After successfully attending this module, students know and understand the basic principles of learning systems and their applications to real world problems.

They know:

- the general idea of learning from data by optimizing.
- different methods to learn from data: Supervised and Unsupervised Learning.

- the mathematical basis and the most important algorithms to train machine learning models on their own.
- how to preprocess data.
- how to construct and monitor a machine learning training procedure.
- how to evaluate and validate machine learning models using different loss functions.
- the basic pitfalls and problems when training models and how to solve them efficiently.

Content:

- Logic and Fuzzy Logic
- Basic concepts of Machine Learning
- Preprocessing
- Supervised Learning
  - Regression
  - Classification
  - Gradient Descent
- Data preparation and preprocessing
- Evaluation and Validation
- Loss Functions
- Unsupervised Learning
- Frameworks and Tools
- Practical applications of modern machine learning algorithms

Literature:

- GOODFELLOW, Ian, Yoshua BENGIO and Aaron COURVILLE, 2016. *Deep learning*. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-33737-3
- BISHOP, Christopher M., 2016. *Pattern recognition and machine learning*. softcover reprint of the original 1st edition 2006. edition. New York, NY: Springer. ISBN 978-1-4939-3843-8
- RUSSEL, and NORVIG, 2022. *Artificial Intelligence - A Modern Approach*. 4. edition. ISBN 978-1-292-40113-3

Additional remarks:

None

Scientific Research Methods

Module abbreviation:	CAI_ScRM	**SPO-No.:**	10
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	2
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Seidel, Christian
Credit points / SWS:	2 ECTS / 2 SWS
Workload:	Contact hours: 23 h Self-study: 27 h Total effort: 50 h
Subjects of the module:	Scientific Research Methods (CAI_ScRM)
Lecture types:	SU/Ü - integrated lecture and exercises
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN - participation without/with success (CAI_ScRM)

Requirements:
To pass the module a written research proposal of 1-3 pages is necessary.

Prerequisites according examination regulation:

None

Recommended prerequisites:

none

Objectives:

After attending the lecture, students will be able:

- to classify the content and form of scientific papers, as well as to write first scientific papers themselves.
- to apply scientific tools.
- to work with sources and cite correctly.
- to classify and choose research methods.
- apply project management to research projects.
- to design presentations.
- to understand the ethical context and evaluate ethical questions.

Content:

- Science and research
- Scientific works
- Scientific working skills

- Project Management
- Presentation skills
- Bachelor thesis, master thesis, dissertation
- Ethics in science
- Legal considerations

Literature:

- PRUZAN, Peter, 2016. *Research methodology: the aims, practices and ethics of science*. [Cham]: Springer. ISBN 978-3-319-27166-8, 978-3-319-27167-5
- TURNER, Kathy, 2011. *Essential academic skills*. 2. edition. Oxford: Oxford Univ. Press. ISBN 978-0-19-557605-4, 0-19-557605-5

Additional remarks:

None

Software Engineering

Module abbreviation:	CAI_SwEng	**SPO-No.:**	11
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Hafenrichter, Bernd
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	11.1: Software Engineering (CAI_SwEng) 11.2: Practical Course Software Engineering (CAI_SwEngPr)
Lecture types:	11.1 SU/Ü - integrated lecture and exercises 11.2: Pr - laboratory
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

11.1: schrP90 - written exam, 90 minutes (CAI_SwEng)
11.2: LN - participation without/with success (CAI_SwEngPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 11.2).

To successfully pass the course, continuous participation and individual (re)processing of tasks on the computer are mandatory - especially if no or only little previous experience in the field of software development is available. In the context of the practical course, various tasks that deal with different topics of the lecture are to be worked on independently. For this purpose, the students have to work on up to 10 task sheets. The solutions are to be handed in individually or in small groups within a given time schedule (usually every 1 - 2 weeks), whereby questions about the solution concept created are to be answered. The schedule is aligned with the progress of the lecture. Only if 80% of the tests are acquired in time, the performance record (predicate "passed with success") is considered to be achieved.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

Basics of programming
Basics of Computer Science

Objectives:

After attending the course, the students:

- have the basic competences for the development of small and medium-sized software systems.
- are familiar with the basic steps of software engineering.
- know existing quality models and their meaning for the development of software.
- can describe requirements to a software system in a structured way.
- know fundamental architecture principles and can uses these for creating software architectures.
- can use selected diagrams of the UML for the description and documentation of a software system.
- know the basic process of testing.
- can use different testing strategies.
- are familiar with basic procedure models for software development.

After attending the practical course:

- the students have their own practical experience in applying software engineering methods.
- the students have practical experiences in the analysis, planning and conversion of software systems.
- the listeners can document requirements to a software product in a structured way.
- the students are able to describe software system with the help of UML diagrams.
- are the listeners able to design and document the software architecture.
- are the students in the position to convert the architecture of a software.
- students are able to specify test cases and document test executions.

Content:

Introduction

- Software Engineering
- Software Quality

Requirements engineering

- Importance
- Approach
- Stakeholders
- System context
- Elicitation methods
- Documentation
- Use cases
- Class diagrams
- State diagrams

Software Architecture & Design Basics

- Architecture principles
- Component architecture
- Entity-Boundary-Controller
- Sequence diagrams
- Component diagrams

Implementation

- Coding rules
- Persistence Layer

Testing

- Principles
- Test planning
- Dynamic testing
- Blackbox testing
- Whitebox testing

Requirements engineering

- Stakeholderanalyses and System context
- Literal documentation of requirements
- Use cases modelling
- Class diagrams
- State diagrams

Software architecture & design

- Derive a component architecture with Entity-Boundary-Controller and Sequence diagrams
- Component diagrams

Implementation

- Implementation of a component architecture

Testing

- Blackboxtesting
- Whiteboxtesting

Literature:

- SOMMERVILLE, Ian, 2015. *Software Engineering, Global Edition*. 10. edition. ISBN 9781292096131, 978-1292096131
- BLACK, Rex, Erik VAN VEENENDAAL and Dorothy GRAHAM, 2019. *Foundations of Software Testing: ISTQB Certification*. 4. edition. ISBN 1473764793, 978-1473764798
- SEIDL, Martina and others, 2015. *UML @ Classroom: An Introduction to Object-Oriented Modeling (Undergraduate Topics in Computer Science).* ISBN 3319127411, 978-3319127415
- VOGEL, Oliver and Ingo ARNOLD, 2011. *Software Architecture: A Comprehensive Framework and Guide for Practitioners*. 2011. edition. ISBN 3642197353, 978-3642197352

Additional remarks:

None

Web Technologies

Module abbreviation:	CAI_WebT	**SPO-No.:**	12
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Hagerer, Andreas
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	12.1: Web Technologies (CAI_WebT) 12.2: Practical Course Web Technologies (CAI_WebTPr)
Lecture types:	12.1: SU/Ü - lecture with integrated exercises (CAI_WebT) 12.2: Pr - laboratory (CAI_WebTPr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

12.1: schrP90 - written exam, 90 minutes (CAI_WebT)
12.2: LN - participation without/with success (CAI_WebTPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO No. 12.2).

Five test certificates must be acquired in the practical course. The lecturer will award one testate each upon successful completion of the assignment. In total, at least 80% of the testates must be completed, which cover essential topics of the lecture.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded. Advancement requirement for the second stage of studies.

Recommended prerequisites:

Programming concepts like Serialization and Processing of Markup Languages in Python

Objectives:

After attending the course, students

- have theoretical knowledge of modern client- and server-side web technologies.
- are able to specify web pages with HTML and to design the layout of the pages by using CSS.
- are able to develop dynamic web pages by using the corresponding possibilities of JavaScript.
- will be able to develop web applications using Python.

- are able to design and implement standard software architectures for web applications.
- know web services and REST to define server interfaces and can develop servers using these interfaces.

After the practical course students know the basic structure of a web applications, and how a web browser interacts with a web server.

Content:

Core technologies of the Web:

- HTML and CSS (HyperText Markup Language and Cascading Style Sheets)
- HTTP (HyperText Transfer Protocol)
- Client-side Programming Using JavaScript
- Ajax (Asynchronous JavaScript & XML) and JSON (JavaScript Object Notation)
- Server-side Programming Using Python and JavaScript

Subsidiary topics:

- Web Services (REST), Web Security and Privacy Tools
- Responsive Website Design

Programming tasks

- introducing to the Hypertext Transfer Protocol (HTTP) request/response cycle and obtaining an understanding of Hypertext Markup Language (HTML), as well as the overall structure of a Django application
- exploring the Model-View-Controller (MVC) pattern for web applications and how it relates to Django

Literature:

- FELKE-MORRIS, Terry Ann, 2017. *Web development and design foundations with HTML5*. 8. edition. Boston: Pearson. ISBN 978-1-292-16408-3
- GAGLIARDI, Valentino, 2021. *Decoupled Django: Understand and Build Decoupled Django Architectures for JavaScript Front-ends* [online]. Berkeley, CA: Apress PDF e-Book. ISBN 978-1-4842-7144-5. Available via: https://doi.org/10.1007/978-1-4842-7144-5.
- GUTIERREZ, Carlos, FERNÁNDEZ-MEDINA, Eduardo, PIATTINI, Mario, 2010. *Web services security development and architecture: theoretical and practical issues* [online]. Hershey; New York: Information Science Reference PDF e-Book. ISBN 978-1-60566-951-9. Available via: http://services.igi-global.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-60566-950-2.
- MANVI, Sunilkumar and Gopal Krishna SHYAM, 2021. *Cloud computing: concepts and technologies*. Boca Raton; London; New York: CRC Press, Taylor & Francis Group. ISBN 978-0-367-55461-3, 978-0-367-55459-0

Additional remarks:

None

Optimization Algorithms

Module abbreviation:	CAI_OpAlg	**SPO-No.:**	13
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Krüger, Max
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total effort: 125 h
Subjects of the module:	Optimization Algorithms (CAI_OpAlg)
Lecture types:	SU/Ü - lecture with integrated exercises (CAI_OpAlg)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

schrP90 - written exam, 90 minutes (CAI_OpAlg)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After successfully completing the module the students ...

- Category Knowledge:
  ... have knowledge of important notations, concepts, and methods of optimization.
- Category Comprehension:
  ... understand the benefit of optimization in the treatment of application problems and as foundation of machine learning and artificial intelligence.
- ... can explain important notations and concepts using examples and thereby understand the essential methods.
- Category Application:
  ... independently solve typical optimization tasks.
- ... recognize optimization problems that arise when working on application problems and solve them with suitable methods.
- ... familiarize themselves with new optimization methods if necessary.

- Category Analysis:
  ... critically question optimization methods with regard to their applicability for existing problems and check the results for plausibility.
- Category Evaluation:
  ... interpret and assess the results in the application context.

After successful participation in the Optimization module, the students will be able to meet the mathematical requirements of the advanced subjects and are able to familiarize themselves with further optimization methods in the area of machine learning and artificial intelligence.

Content:

Overview and foundations:

- Introduction and overview to optimization
- General optimization problem
- Classification of optimization problems and methods
- Topological foundations of n-dimensional real sets
- Functions with several variables and continuity
- Convexity of sets and functions

Analytical optimization:

- Optimization with one variable
- Partial and directional derivatives
- Gradients, Hessian matrix and definiteness-criteria of matrices
- Optimization without constraints I
- Optimization without constraints II
- Optimization with equality-constraints

Numerical optimization:

- Introduction to numerical methods and numerical scalar optimization
- Numerical vector optimization
- Gradient methods I
- Gradient methods II
- Nelder-Mead method

Linear optimization:

- Linear optimization
- Simplex method
- Integer and binary optimization
- Tools for linear optimization I
- Tools for linear optimization II

Graph Optimization

- Graph Theory
- Trees and tree search
- Shortest Paths and Minimal Spanning Trees

Literature:

- DEISENROTH, Marc Peter, A. Aldo FAISAL and Cheng Soon ONG, 2020. *Mathematics for machine learning*. Cambridge: Cambridge University Press. ISBN 978-1-108-45514-5
- AGGARWAL, Charu C., 2020. *Linear algebra and optimization for machine learning: a textbook* [online]. Cham: Springer PDF e-Book. ISBN 978-3-030-40344-7. Available via: https://doi.org/10.1007/978-3-030-40344-7
- DIESTEL, Reinhard, 2017. *Graph theory*. F. edition. Berlin: Springer. ISBN 978-3-662-53621-6, 978-3-662-57149-1

Additional remarks:
None

Algorithms for AI 2

Module abbreviation:	CAI_AAI2	**SPO-No.:**	14
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Schön, Torsten
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	14.1: Algorithms for AI 2 (CAI_AAI2) 14.2: Practical Course Algorithms for AI 2 (CAI_AAI2Pr)
Lecture types:	14.1: SU/Ü - lecture with integrated exercises (CAI_AAI1) 14.2: Pr - laboratory (CAI_AAI1Pr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

14.1: schrP90 - written exam, 90 minutes (CAI_AAI2)
14.2: LN - participation without/with success (CAI_AAI2Pr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 14.2).

Students must successfully complete and submit at least 6 exercise sheets. 9 exercise sheets will be available.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

In this module, students learn to use more advanced algorithms of artificial intelligence and their applications on structures, unstructured and temporal data. The basic idea and mathematical backgrounds of neural networks are introduced. Students learn how to train simple neural networks to learn patterns from data for regression and classification tasks. Further, Deep Learning and its most common architectures are introduced, including Convolutions and recurrent connections. Students learn how to effectively train deep learning networks by choosing optimal hyperparameters and how to avoid overfitting. Thus, methods like Regularization and Dropout are explained. The goal of this module is further to introduce unsupervised learning

to the students, as well as its application to solve clustering problems. The application of unsupervised learning in combination with neural networks is illustrated by introducing autoencoders. In addition, it is shown how to use unsupervised learning methods to reduce the dimensionality of datasets using feature selection and PCA techniques. After successfully attending this module, students know:

- How to handle structured, unstructured and temporal data.
- What a neural network is and how it can be trained using backpropagation.
- How to use different optimizers for neural networks.
- The most important deep learning architectural layers like convolutions.
- How to effectively train neural networks and to avoid overfitting.
- The basic principles of unsupervised learning and their applications to real world problems.
- How to used features selection and PCA methods to reduce the dimensionality of datasets.
- Different forms of collaborative groups work.
- How to gather knowledge and share it within their learning group.
- How to summarize and present the most important information of a specific topic.

Content:

- Learning with structured, unstructured and temporal data
- Basic principles of neural networks
- Backpropagation and different Optimizer
- Convolutional layer
- Recurrent neural networks
- Regularization and Dropout
- Optimizing Hyperparameters
- Unsupervised Learning
  - Clustering and its most important algorithms
  - Autoencoders
  - Dimensionality Reduction

Literature:

- GOODFELLOW, Ian, Yoshua BENGIO and Aaron COURVILLE, 2016. *Deep learning*. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-33737-3
- BISHOP, Christopher M, 2016. *Pattern recognition and machine learning*. New York: Springer. ISBN 978-1-4939-3843-8
- RUSSEL, Stuart and Peter NORVIG, 2021. *Artificial intelligence: a modern approach.* 4. edition. ISBN 978-1-292-40113-3; 1-292-40113-3

Additional remarks:

None

Data Visualization and Data Analytics

Module abbreviation:	CAI_DVsAn	**SPO-No.:**	15
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	3
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Navarro Bullock, Beate
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total effort: 125 h
Subjects of the module:	Data Visualization and Data Analytics (CAI_DVsAn)
Lecture types:	SU/Ü - lecture with integrated exercises (CAI_DVsAn)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

schrP90 - written exam, 90 minutes (CAI_DVsAn)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

Basic knowledge of Python

Objectives:

At the end of the class, students will

- get an understanding of technologies and software tools to handle fundamental steps in the data analysis pipeline.
- know how to acquire data, for example using web scrapers, APIs or data platforms and how to structure them to most conveniently work with them.
- be able to preprocess and manipulate data.
- apply basic data analysis techniques using Python and real word datasets.
- know common methods to answer basic questions about the data and how to interpret the results.
- have an understanding of data presentation and visualization (reporting, graphical analysis, representation of results).

Content:

This course provides a broad overview of principles and algorithms for data analytics and visualization. Specific topics include:

- How to get and structure the data (data collection, usage of web scrapers, APIs etc., data formats, types and structure of data)
- How to process the data (data wrangling and transformation, data reduction, aggregation of data)
- How to analyze data
- How to visualize data (human perception, types of visualizations, visualization design, interactive visualizations, algorithms)
- How to deal with specific types of data (for example time series, text, spatial data)

The lecture is accompanied with (practical) exercises using Python and a selection of visualization tools.

Literature:

- MURRAY, Scott, 2017. *Interactive Data Visualization for the Web*. 2. edition. ISBN 978-1491921289
- MUNZNER, Tamara, 2015. *Visualization analysis & design*. Boca Raton [u.a.]: CRC Press, Taylor & Francis Group. ISBN 978-1-4665-0893-4, 978-1-4665-0891-0
- MCKINNEY, Wes, 2017. *Python for Data Analysis*. 2. edition. ISBN 978-1491957660
- VANDERPLAS, Jake, 2017. *Python Data Science Handbook: Essential Tools for Working with Data*. 1. edition. ISBN 978-1491912058

Additional remarks:

Bonus point regulation: Bonus points are awarded for this lecture according to APO §25 paragraph (2). The bonus points amount to a maximum of 5% of the points awarded in the exam. The exact conditions are deposited in the corresponding Moodle course room.

Database Systems and Big Data Technologies

Module abbreviation:	CAI_DBBD	**SPO-No.:**	16
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	4
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Cato, Patrick
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	16.1: Database Systems and Big Data Technologies (CAI_DBBD) 16.2: Practical Course Database Systems and Big Data Technologies (CAI_DBBDPr)
Lecture types:	16.1: SU/Ü - lecture with integrated exercises 16.2: Pr - laboratory
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

16.1: schrP90 - written exam, 90 minutes (CAI_DBBD)
16.2: LN - participation without/with success (CAI_DBBDPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 16.2).

In order to meet the admission requirements for participation in the final and graded written exam, a semester-long internship must be passed „with success“. For this purpose, a total of one assignment must be successfully completed.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

On successful completion of the course, students are:

- able to explain the characteristics of Big Data and basic data management technologies and techniques.
- are familiar with the basic concepts of relational database systems and are able to create efficient database designs for various use cases.

- work with data stored in a relational DBMS by applying SQL to create database tables, extract, present, and modify data.
- are able to explain the motivation and development of post-relational data management systems.
- are able to describe the essential characteristics of the central categories of NoSQL systems, their advantages and limitations.

The lecture is supplemented by the practical course in order to deepen the theoretical concepts in practice. In the practical course, the contents of the lecture are deepened by means of practical tasks.

Content:

- Introduction: Definition of Big Data, Big Data Use Cases, data types, data structures
- Relational Database Management Systems: Overview of core concepts (ER-Diagrams, SQL, index, normalisation, transactions, tuning)
- NoSQL Systems: Motivation and core concepts (CAP, Replication, Wide Column Stores, Graph database, Document Stores, Key-Value Stores)
- Optimized storage formats for Big Data (Parquet, Avro, ORC)
- Distributed filesystems and distributed computing frameworks (Hadoop, MapReduce, Spark)
- Data Lake architectures and modern data management concepts

Literature:

- PERKINS, Luc, 2018. *Seven Databases in Seven Week: A Guide to Modern Databases and the Nosql Movement*. 2. edition.
- KLEPPMANN, Martin, 2017. *Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems*. ISBN 978-1-449-37332-0
- LEMAHIEU, Wilfried, Seppe VANDEN BROUCKE and Bart BAESENS, 2018. *Principles of Database Management: The Practical Guide to Storing, Managing and Analyzing Big and Small Data*. 1. edition. ISBN 978-1107186125

Additional remarks:

None

Spoken and Natural Language Understanding

Module abbreviation:	CAI_NatL	**SPO-No.:**	17
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	4
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Georges, Munir
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	17.1: Spoken and Natural Language Understanding (CAI_NatL) 17.2: Practical Course Spoken and Natural Language Understanding (CAI_NatLPr)
Lecture types:	17.1: SU/Ü - lecture with integrated exercises 17.2: Pr - laboratory
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

17.1: schrP90 - written exam, 90 minutes (CAI_NatL)
17.2: LN - participation without/with success (CAI_NatLPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 17.2).

Active and successful participation in the practical course is a prerequisite for taking the written examination in the subject "Spoken and Natural Language Understanding": The practical course comprises 3 projects on different topics, which must be successfully completed and presented in time.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

Mathematics
Probability Theory and Statistics
Programming

Objectives:

After successful participation, students will be able to,

- explain the basic features of speech and text comprehension.
- analyse and evaluate text and speech signals.

- classify existing applications and assess future developments.
- use basic speech/text algorithms to solve problems.

Content:

Text processing: natural and formal languages, grammar and statistics, language models

- Audio processing: frequency analysis, feature recognition, acoustic models
- Statistical models and neural networks for speech processing
- Applications:
  - Text analysis, search engines, language understanding (NLP).
  - Translation (NMT)
  - Speech Recognition (ASR)
  - Speech synthesis (TTS)
  - Speech Dialogues/Chatbots

Literature:

- EISENSTEIN, Jacob, 2019. *Introduction to natural language processing*. Cambridge, MA: The MIT Press. ISBN 978-0-262-04284-0, 0262042843
- GOLDBERG, Yoaf, 2016. *A primer on neural network models for natural language processing*. ISBN https://doi.org/10.1613/jair.4992
- GOODFELLOW, Ian, Yoshua BENGIO and Aaron COURVILLE, 2016. *Deep learning*. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-03561-3
- HUANG, Xuedong, Alex ACERO and Hsiao-Wuen HON, 2001. *Spoken language processing: a guide to theory, algorithm, and system development*. Upper Saddle River, NJ: Prentice Hall PTR. ISBN 0-13-022616-5
- JURAFSKY, Dan and James H. MARTIN, 2009. *Speech and language processing: an introduction to natural language processing, computational linguistics, and speech recognition*. 2. edition. Upper Saddle River: Pearson Education International, Prentice Hall. ISBN 0-13-504196-1, 978-0-13-504196-3
- MANNING, Christopher D. and Hinrich SCHÜTZE, 2003. *Foundations of statistical natural language processing*. 6. edition. Cambridge, Mass. [u.a.]: MIT Press. ISBN 0-262-13360-1, 978-0-262-13360-9
- ROCHE, Emmanuel and Yves SCHABES, c1997. *Finite-state language processing*. Cambridge, Mass.: MIT Press. ISBN 0-262-18182-7, 0-262-29095-2

Additional remarks:

None

Computer Vision

Module abbreviation:	CAI_CVis	**SPO-No.:**	18
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	4
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Aubreville, Marc
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	18.1: Computer Vision (CAI_CVis) 18.2: Practical Course Computer Vision (CAI_CVisPr)
Lecture types:	18.1: SU/Ü - lecture with integrated exercises (CAI_CVis) 18.2: Pr - laboratory (CAI_CVisPr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

18.1: schrP90 - written exam, 90 minutes (CAI_CVis)
18.2: LN - participation without/with success (CAI_CVisPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 18.2).

In the practical course, the contents of the lecture are deepened by means of practical tasks. In order to obtain the admission requirement for participation in the final and graded written examination, a semester-long practical course must be passed "with success". Successful completion of the accompanying practical course is a prerequisite for participation in the examination. To receive the certificate of achievement, a project must be worked on and submitted. The project results must be summarized in a written report and presented in a short presentation. The task set in the project as well as the presentation will be evaluated by the lecturer. On the basis of this evaluation, admission for participation in the final and graded written examination will be decided.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

In the module students learn the theoretical basics and the application of classical as well as modern image processing algorithms. After successful participation they are able to:

- describe how image data are created and how they are represented on a computer.
- to implement basic algorithms of image manipulation independently.
- classify images with the help of Deep Learning.
- recognize and classify objects in images with the help of Deep Learning.
- segment images semantically in an automated way.
- validate and correctly interpret results from Deep Learning networks.
- work with relevant computer vision frameworks (e.g. OpenCV, PyTorch, Tensorflow).
- Correctly use, understand, and independently apply modern network architectures for various image processing applications (e.g., Human Pose Estimation, GANs, Attention Mechanism).

Content:

Understanding of image data and their representation in modern computer systems

- Classic image processing
  - Transformations
  - Image manipulations
  - Feature generation (edge detection, histograms, templates, textures)
- Modern image processing
  - Fundamentals of Deep Learning
  - Convolutional Neural Networks
  - Classification
  - Pre-processing (augmentation, normalization, ...)
  - Object Detection
  - Semantic segmentation
  - Instance segmentation
  - Image registration
  - Evaluation of trained models and loss functions
  - Parameterization and initialization of DNNs
  - Adversarial Networks
  - Frameworks (PyTorch, Tensorflow, Keras)

Students learn and practice the practical use of classical and modern algorithms of image processing. They independently implement simple algorithms and train state-of-the-art Deep Learning models using Open-Source frameworks on the basis of practical examples.

Literature:

- GOODFELLOW, Ian, Yoshua BENGIO und Aaron COURVILLE, 2016. *Deep learning*. Cambridge, Massachusetts; London, England: The MIT Press. ISBN 978-0-262-03561-3

Additional remarks:

None

Algorithms for AI 3

Module abbreviation:	CAI_AAI3	**SPO-No.:**	19
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	4
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Hahndel, Stefan
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	19.1: Algorithms for AI 3 (CAI_AAI3) 19.2: Practical Course Algorithms for AI 3 (CAI_AAI3Pr)
Lecture types:	19.1: SU/Ü - lecture with integrated exercises (CAI_AAI3) 19.2: Pr - laboratory (CAI_AAI3Pr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

19.1: schrP90 - written exam, 90 minutes (CAI_AAI3)
19.2: LN - participation without/with success (CAI_AAI3Pr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-Nor. 19.2).

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

This module completes the trilogy of AI algorithms. After the basics and techniques of statistical/stochastic AI have been introduced and learned in the first two modules, this module supplements the holistic overview with selected, practice-relevant application areas of machine learning methods, with approaches of distributed AI and with the most important concepts and methods of symbolic AI.

After successfully completing this module, the students:

- can reflect the purpose and background of selected machine learning applications that are frequently used in practice.
- understand that distributed AI allows not to join the necessary huge amounts of data at a central site, but to analyze the data directly at the source.

- are proficient in some concepts and techniques of symbolic AI, where the solution strategy is not learned from sample data but is based on knowledge that is represented symbolically. Such methods are used when no data is available for the learning process or when the task can be represented in terms of logical relationships.
- are able to formally represent knowledge using appropriate models and languages.
- have practical experience in applying formal knowledge models within knowledge-based systems. This objective involves the use of formal knowledge representation techniques to design and implement systems capable of intelligent behaviour, such as expert systems and automated reasoning systems.

The practical course accompanying the course "Algorithms for AI 3" serves to teach and train the students to put into practice the knowledge they have acquired in the lecture. In addition, to preparatory exercises, the students must independently solve four programming tasks of increasing complexity during the semester and write executable programs. The finished programs are presented to the respective lecturer and thus also serve as proof of performance for admission to the examination.

Content:

- Selected, practice-relevant application areas of machine learning methods
  - Recommender Systems
  - Fraud Detection (banking, financial services)
  - Biometric Recognition
  - Sentiment Analysis
- Distributed AI
  - Multi-agent Systems
  - Swarm Intelligence
- Concepts and Methods of Symbolic AI
  - Logic Programming (Prolog)
  - Graph problem solving: application to game problems
  - Machine Reasoning
  - Constraint Satisfaction Problems and Constraint Logic Programming
  - Knowledge representation: logic, inference, rule-based systems and expert systems

Practical Course:

- Machine Learning
- Search Algorithms
- Logic / Prolog
- Constraint Satisfaction Problems

Literature:

- RUSSEL, Stuart J. and Peter NORVIG, 2016. . 3. edition. ISBN 978-1292153964
- BRAMER, Max, 2013. *Logic Programming with Prolog*. 2. edition. ISBN 978-1447154860
- RUSSEL, Stuart and Peter NORVIG, 2021. *Artificial Intelligence: A Modern Approach*. 4th edition. ISBN 978-1-292-40113-3

Additional remarks:

None

Seminar

Module abbreviation:	CAI_Sem	**SPO-No.:**	20
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	4
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	3 ECTS / 2 SWS
Workload:	Contact hours: 23 h Self-study: 52 h Total effort: 75 h
Subjects of the module:	Seminar (CAI_Sem)
Lecture types:	S - seminar (CAI_Sem)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

SA - seminar paper and presentation (CAI_Sem)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending the module, the students

- have the ability to independently acquire special technical knowledge (literature research, analysis, conclusions) and can present this comprehensibly in the context of an oral presentation with the help of suitable media.
- are able to follow a technical presentation critically and to discuss the contents with the speaker.
- have strengthened their interdisciplinary and communicative competences.
- can summarize the content of their presentation in the form of a short written paper.

Content:

The subject of the seminar changes from course to course. It is a subject from computer science and artificial intelligence for which there is suitable technical literature. This literature is provided by the instructor. It is also the compulsory literature for the seminar.

In the course of the seminar, each student arranges a 30- to 45-minute teaching unit on a topic related to the course subject. The topic will be assigned to him or her by lot or selection at the beginning of the semester.

- In the preparation phase, each student must conduct a literature research on his or her topic and compile the results in a presentation
- He or she offers this presentation in an oral talk that should last about 30 and 45 minutes. The remaining time is reserved for discussing the presentation and giving feedback to the presenter
- In addition, the student is required to prepare a written paper on the presented topic. This paper should summarize the main contents of the talk in full text and should be between 10 and 20 pages long (excluding figures, tables and indexes)

At the beginning of the semester, the instructor communicates detailed information on due dates and his expectations regarding the structure of the presentation and the written paper.

Literature:

Depends on the subject matter of the seminar and will be announced by the instructor at the beginning of the semester.

Additional remarks:

None

Cyber Security

Module abbreviation:	CAI_CySec	**SPO-No.:**	21
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	6
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Eggendorfer, Tobias
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	21.1: Cyber Security (CAI_CySec) 21.2: Practical Course Cyber Security (CAI_CySecPr)
Lecture types:	21.1: SU/Ü - lecture with integrated exercises 21.2: Pr - laboratory
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

21.1: schrP90 - written exam, 90 minutes (CAI_CySec)
21.2: LN - participation without/with success (CAI_CySecPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (SPO-No. 21.2).

The credit certificates to be acquired in the practical course encompass several tasks which must be completed successfully:

- common security tools
- Security programming in Python
- Threat and risk analysis
- source code analysis
- penetration testing

The solutions of the tasks can and should be worked out in small groups to promote social and professional competence. The finished solutions are to be processed individually within a fixed schedule. The tasks, the schedule, and the way the results are presented (uploading to Moodle, presentation of the results, ...) will be announced at the beginning of the lecture.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending this module...

- students know current threats for IT systems and applications, essential security risks, and are able to evaluate and estimate the risk potential for their own projects using a risk analysis.
- students know the basic building blocks and principles for building secure systems and applications, e.g. encryption, authentication procedures, public key infrastructures.
- students can design a suitable IT security strategy based on a risk analysis, taking into account both organizational and technical aspects and assessing their effectiveness in practice.
- students know different attacks on methods of artificial intelligence and can avoid them.
- Students know different areas of application for artificial intelligence in IT security (e.g. intrusion detection).

Content:

- Threats to IT systems and applications
- Building blocks for IT security
  - cryptography (symmetric and asymmetric encryption, hash functions, signature, key exchange)
  - public key infrastructures
- Secure systems
  - authentication
  - access control
  - hardening of systems
  - trusted execution
  - isolation, ...
- Network security (IPSec, TLS, IEEE 802.1x, RADIUS, firewalls, ...)
- Security principles (Defense in Depth, Least Privilege, Zero Trust, ...)
- Software-related vulnerabilities and how to avoid them
  - Secure software development, SDLC
  - Typical vulnerabilities such as buffer and heap overflows
- Information security management
  - security models and security policies
  - Risk analysis of IT structure and IT-supported business processes
- Threats specific to artificial intelligence and how to avoid them
- Methods of artificial intelligence in IT security (e.g. intrusion detection, malware detection, …)

Literature:

- ANDERSON, Ross, 2021. *Security Engineering: A Guide to Build Dependable Distributed Systems*. ISBN 978-1119642787
- AUMASSON, Jean-Philippe. *Serious Cryptography - A Practical Introduction to Modern Encryption.* ISBN 9781593278267
- DEOGUN, Daniel, 2019. *Secure By Design*. ISBN 978-1617294358
- TARANDACH, Izar and Matthew J. COLES. *Threat Modeling: A Practicial Guide for Development Teams*. ISBN 978-1492056553
- PARISI, Alessandro. *Hands-On Artificial Intelligence for Cyberscurity*. ISBN 978-1789804027

Additional remarks:

None

Human-Computer Interaction and Explainable AI

Module abbreviation:	CAI_HCI	**SPO-No.:**	22
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	6
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Riener, Andreas
Credit points / SWS:	7 ECTS / 6 SWS
Workload:	Contact hours: 70 h Self-study: 105 h Total effort: 175 h
Subjects of the module:	22.1: Human-Computer Interaction and Explainable AI (CAI_HCI) 22.2: Practical Course Human-Computer Interaction and Explainable AI (CAI_HCIPr)
Lecture types:	22.1: SU/Ü - lecture with integrated exercises (CAI_HCI) 22.2: Pr - laboratory (CAI_HCIPr)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

22.1: schrP90 - written exam, 90 minutes (CAI_HCI)
22.2: LN - participation without/with success (CAI_HCIPr)

Requirements:

A prerequisite for participation in the written examination is a successfully completed practical course (see SPO-No. 22.2).

Within the framework of the practical course, 6 practical tasks (on core topics of the lecture) must be solved in groups of 2 or 3. The practical course is held in blocks in the middle of the semester. For each practical task, papers/protocols are to be prepared and handed in - in particular, importance is attached to a self-interpretation of the results. Only if all tasks are handed in on time (processing time per task usually 2 weeks, deadlines see Moodle), the performance record (entrance requirement for lecture exam) is considered to be fulfilled.

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending the module and actively participating in the course

- ...students know the Usabililty Life Cycle and can name and apply its individual phases.

- ...students are able to list and correctly use common creativity technologies.
- ...know common prototyping methods and have acquired the competence to select and apply the best possible method for a concrete scenario.
- ...have acquired the ability to distinguish and correctly apply models and theories for measuring interaction performance.
- ...students have acquired comprehensive basics of qualitative and quantitative assessment of human-machine interaction.
- ...students understand basic human information processing and know why you need to consider and use this knowledge in interaction design.
- ...students are familiar with relevant methods for simple user studies and are able to apply them.
- ...students are able to design and conduct user studies and interpret the results.
- ...students know standardized questionnaires and have the competence to design simple questionnaires themselves and to conduct questionnaire surveys and interviews.
- ...students are able to identify and illustrate existing approaches in Explainable AI.
- ...students have acquired the ability to discuss and compare different methods for increasing system interpretability and transparency.
- ...students are able to identify and describe different ways of evaluating system explainability, accountability and intelligibility.
- ...students are able to identify and describe how to design interfaces to increase AI system predictability.

Self- and social competences:

After completion of the module

- ...students have sufficient ability to plan, conduct, document, interpret and discuss user studies in a group.
- ...know the individual phases in the planning and execution of usability/UX studies and are thus able to independently conduct research (e.g., thesis).

Content:

This course covers, embedded in the User-Centered Design process, methodological knowledge for the targeted evaluation of human-machine interfaces, the generation of ideas and prototypes in different product development phases, as well as basic knowledge about technologies for human-machine interaction. The module is supplemented by an in-depth treatment of explainable artificial intelligence (XAI).

Lectures

- Definitions of terms and key constructs
- The human-centered design process
- Scientific evaluation of human-machine interfaces (study design, hypothesis testing, etc.)
- Human factors" fundamentals: "Human-in-the-loop" systems (input/output, decision making, etc.)
- Design principles (colors, shapes, Gestalt law, etc.)
- Prediction models (Fitts's law, Hicks's law, GOMS, KLM, etc.)
- Input and output devices for 2D/3D
- Definition of Explainable AI (XAI)
  - Explanations in different fields of AI
  - The role of humans
  - Evaluation protocols and metrics
- Explainable Machine Learning
  - What is a Black Box?
  - Interpretable, Explainable and Comprehensible Models
  - Open the Black Box Problem

Practical course

- Structured application of the human-centered design process
- Design and implementation of user studies
- Requirements elicitation
- Idea generation and prototyping (sketching, wireframes, video-, soft- and hardware prototyping)
- Realization and evaluation of XAI applications
- Application of evaluation methods (interviews, questionnaires, lab and field experiments)

Literature:

- LAZAR, Jonathan, Jinjuan Heidi FENG and Harry HOCHHEISER, 2017. *Research methods in human-computer interaction*. S. edition. Cambridge, MA: Morgan Kaufmann Publishers, an imprint of Elsevier. ISBN 978-0-12-809343-6, 0-12-809343-9
- DIGNUM, Virginia, 2019. *Responsible Artificial Intelligence: how to develop and use AI in a responsible way* [online]. Cham: Springer PDF e-Book. ISBN 978-3-030-30371-6. Available via: https://doi.org/10.1007/978-3-030-30371-6
- LEE, John D. and others, 2017. *Designing for people: an introduction to human factors engineering*. 3. edition. Charleston, SC: CreateSpace. ISBN 978-1-5398-0800-8, 1-5398-0800-9
- MILLER, Tim, 2019. Explanation in artificial intelligence: Insights from the social sciences. In: *Artificial intelligence*. (267), p.1-38. ISSN https://doi.org/10.1016/j.artint.2018.07.007
- JOSHI, Ameet V., 2020. *Machine learning and artificial intelligence* [online]. Cham: Springer PDF e-Book. ISBN 978-3-030-26622-6. Available via: https://doi.org/10.1007/978-3-030-26622-6
- FIELD, Andy and Graham HOLE, 2011. *How to design and report experiments*. R. edition. Los Angeles [u.a.]: Sage. ISBN 978-0-7619-7383-6, 978-0-7619-7382-9

Additional remarks:

None

Business Administration and Entrepreneurship

Module abbreviation:	CAI_BAEnt	**SPO-No.:**	23
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	6
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total effort: 125 h
Subjects of the module:	Business Administration and Entrepreneurship (CAI_BAEnt)
Lecture types:	SU/Ü - lecture with integrated exercises (CAI_BAEnt)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN – written paper (seminar paper) 10-15 pages with presentation 15-30 minutes

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After successful participation in this module, students

- have an overview of the object of study, approaches and differentiation of business administration.
- have acquired the ability to understand companies as carriers of economic activity from the perspective of value-oriented thinking and acting.
- have the ability to comprehend constitutive decisions and to assess the application purposes of different legal forms.
- can describe the essential characteristics of corporate responsibility and leadership.
- are able to describe and explain fundamental areas of a company (e.g. materials management, production management, marketing and sales, investment and financing) both internally and externally using operational goals, functions and processes.
- are able to describe the essential characteristics and procedures in innovation management.
- understand the essential aspects of entrepreneurship and are able to apply them in a practical context.

Content:

• Basic concepts of business administration
• Constitutive decisions
• Leadership and management
• Materials and production management
• Marketing and sales
• Investment management
• Innovation management
• Entrepreneurship
  ○ Generating Business Ideas
  ○ Business Models
  ○ Case Studies and Practical Examples (TOPSIM)

Literature:
Appropriate literature will be announced by the instructor at the beginning of the semester.
Additional remarks:
None

Project Management

Module abbreviation:	CAI_PrMgmt	SPO-No.:	24
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	6
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total effort: 125 h
Subjects of the module:	Project Management (CAI_PrMgmt)
Lecture types:	SU/Ü - lecture with integrated exercises (CAI_PrMgmt)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

schrP90 - written exam, 90 minutes (CAI_PrMgmt)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending the module, the students

- have the basic skills for the management of small and medium-sized IT projects.
- be familiar with the relevant steps in the preparative planning phase of a project.
- be able to organize an adequate project kick-off and to carry out all necessary preparatory work and analyses.
- be able to plan a project in detail.
- know several methods to analyse an ongoing project and to make trend statements about its progress.
- understand relevant dependencies in the course of projects and be able to control of a project based on well-founded methods.
- be familiar with key approaches and methods of agile project management.
- have practices central aspects of project management on a sample case by means of group exercises.
- have had the opportunity to demonstrate and discuss their results in a short presentation.

Content:

1. Basics
   - Definition of project
   - Project triangle (time, budget, scope)
   - Project organization
2. Preparing a project
   - Process models
   - Goal definition
   - Stakeholder analysis / management
   - Risk analysis / management
   - Scope and kick-off
3. Planning a project
   - Work breakdown structure
   - Schedule / network maps
   - Effort estimations
   - Resource planning
4. Implementation of a project
   - Progress and trend analysis
   - Cost management
   - Reporting and communication
   - Project control and change management
5. Agile project management
   - Basic concepts
   - The Agile Manifesto
   - IT Kanban
   - Scrum
   - Hybrid project management

Group exercises will be performed for key contents to consolidate what has been learned.

Literature:

Appropriate literature will be announced by the instructor at the beginning of the semester.

Additional remarks:

None

Project

Module abbreviation:	CAI_Proj	**SPO-No.:**	25
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	6
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	5 ECTS / 2 SWS
Workload:	Contact hours: 23 h Self-study: 102 h Total effort: 125 h
Subjects of the module:	Project (CAI_Proj)
Lecture types:	Prj - project (CAI_Proj)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

ProjA - Project report (5-25 pages) and presentation (15 min.) (CAI_Proj)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending the module, the students

- have experience with at least one specific project management method.
- have become acquainted with specific tools that can be used in the course of an IT project.
- have learned to deal with technical and non-technical problems that may arise during the implementation of a project lasting several weeks.
- have acquired the ability to analyse a complex technical problem and to work on it successfully in a team over the course of a semester.
- are able to report in varying but always appropriate detail on the progress of the project in oral and/or written form.

Content:

Working on a semester-long project task in the field of Computer Science and Artificial Intelligence in a team.

Generally, the projects are carried out in cooperation with external companies or the THI research institutes. Alternatively, instructors can also specify project tasks that are to be worked on as part of their teaching or research activities.

Project management and organization are carried out by students. The decision about which project management method to use is up to the project team. The instructor acts only as a coach and/or client.

At the beginning of the project, the instructor clearly communicates his expectations regarding deadlines, outcomes and form of presentation to be followed by all students. This includes:

- frequency, form, and duration of project management meetings
- the way in which the team or subgroup members should work together
- type and scope of the deliverables to be provided
- nature and extent of individual contributions by students
- grading criteria

Literature:

No general literature is required.

Additional remarks:

None

Ethics and Law

Module abbreviation:	CAI_EthLaw	**SPO-No.:**	26
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	7
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Uhl, Matthias
Credit points / SWS:	5 ECTS / 4 SWS
Workload:	Contact hours: 47 h Self-study: 78 h Total effort: 125 h
Subjects of the module:	Ethics and Law (CAI_EthLaw)
Lecture types:	SU/Ü - lecture with integrated exercises (CAI_EthLaw)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN - project report. Seminar work. Written composition approx. 10-15 pages with presentation 15-30 minutes. (CAI_EthLaw)

Requirements:
None

Prerequisites according examination regulation:

This module can only be taken if the second study section has been achieved. For this purpose, at least 42 credit points (ECTS) from the first study section must be recorded.

Recommended prerequisites:

None

Objectives:

After attending the module, the students

- are familiar with basic principles of ethics and the specificities of the ethics of AI.
- are able to distinguish between normative and descriptive arguments in tech ethics.
- are capable to critically reflect on technological developments against the background of normative theories.
- can apply abstract ethical concepts to concrete technological case studies.
- can explicate and question their own moral standpoint.
- are familiar with legal foundations of dealing with AI.

Content:

- Important categories of the ethics of technology
- Novel questions raised by the ethics of artificial intelligence

- Ethical fallacies
- Introduction to the most important normative theories
- Risk ethics of technology
- Moral agency and machine ethics
- Ethics of human-machine interaction
- Behavioral ethics and the science of biases
- Experiments in the ethics of technology and artificial intelligence
- Human enhancement and transhumanism
- Case studies in ethics
- Legal foundations
- Legal specificities of artificial intelligence

Literature:

- LIAO, Matthew, 2020. *Ethics of Artificial Intelligence*. 1. edition. ISBN 978-0190905040
- FRANKENA, William, 1973. *Ethics*. ISBN 978-0132904780

Additional remarks:

None

Seminar Bachelor's Thesis

Module abbreviation:	CAI_BaSem	**SPO-No.:**	28.1
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	7
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	3 ECTS / 2 SWS
Workload:	Contact hours: 23 h Self-study: 52 h Total effort: 75 h
Subjects of the module:	Seminar Bachelor's Thesis (CAI_BaSem)
Lecture types:	S - seminar (CAI_BaSem)
Usability for other study programs:	None

Examinations:

SA - Presentation (CAI_BaSem)

Requirements:
None

Prerequisites according examination regulation:

The topic of the Bachelor's thesis can be issued at the beginning of the sixth semester at the earliest. The prerequisite is the successful completion of the internship semester.

Recommended prerequisites:

None

Objectives:

The students are familiar with the techniques of scientific work and are able to project, delimit, classify, structure and design their Bachelor's thesis. They are able to cite correctly and avoid plagiarism.

Content:

- General informative meeting on the subject of writing a Bachelor's thesis, which is aimed at all candidates of a year.
- Regular discussion of the progress of the individual Bachelor's thesis in a face-to-face meeting with the respective supervisor while the thesis is being prepared.

Literature:

No general literature is required.

Additional remarks:
None

Bachelor‘s Thesis

Module abbreviation:	CAI_Thesis	**SPO-No.:**	28.2
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	7
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	only winter term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	12 ECTS / 0 SWS
Workload:	Contact hours: 0 h Self-study: 300 h Total effort: 300 h
Subjects of the module:	Bachelor‘s Thesis (CAI_Thesis)
Lecture types:	BA - Bachelor Thesis (CAI_Thesis)
Usability for other study programs:	None

Examinations:

BA - Bachelor-Thesis (CAI_Thesis)

Requirements:
None

Prerequisites according examination regulation:

The topic of the Bachelor’s thesis can be issued at the beginning of the sixth semester at the earliest. The prerequisite is the successful completion of the internship semester.

Recommended prerequisites:

None

Objectives:

The students are able to work independently on a task from the field of Computer Science and Artificial Intelligence using scientific methods and according to scientific quality standards within a given period of time. This includes the research and presentation of the state of the art, the development of the necessary theoretical foundations, the problem-oriented and independent development of proposals for solution, as well as the presentation and interpretation of the results.

Content:

Preparation of a Bachelor's thesis, including

- Development and concretization of a relevant problem statement
- Preparation of a work plan and time schedule
- Literature research
- Presentation of relevant basics
- Discussion of appropriate methods for a solution

- Justified selection and application of a problem-solving approach
- Test, evaluation of results and drawing of conclusions against the background of the existing constraints
- Written formulation and, if necessary, suitable visualizations (diagrams, tables, etc.)
- Final review of the thesis for logical coherence and linguistic correctness and comprehensibility

In general, the student seeks a topic for the thesis autonomously. Topics are either offered within the university by professors or scientific staff members via notice boards (also online) or arise from the cooperation of the student with an external company. In case of an external topic, it is advisable to outline the topic and the envisaged approach in a short exposé. This groundwork makes it easier to approach a professor at the university and get him to be the first examiner.

Literature:

No general literature is required.

Additional remarks:

None

Pre-Internship Seminar

Module abbreviation:	CAI_PreS	**SPO-No.:**	29
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	5
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	winter and summer term

Responsible for module:	Tiedemann, Wolf-Dieter
Credit points / SWS:	2 ECTS / 1 SWS
Workload:	Contact hours: 12 h Self-study: 38 h Total effort: 50 h
Subjects of the module:	Pre-Internship Seminar (CAI_PreS)
Lecture types:	S - seminar (CAI_PreS)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN - participation without/with success (CAI_PreS)

Requirements:
None

Prerequisites according examination regulation:

All examinations of the first study section must have been passed and at least 20 credit points must have been achieved from modules of the first two semesters of the second study section.

Recommended prerequisites:

None

Objectives:

After successful participation in the module, the students are able

- to behave appropriately in everyday situations of professional cooperation.
- to reflect on their own communication skills and team competence and to use both more purposefully.
- to analyze conflicts and their dynamics.
- to develop goal-oriented solutions in dealing with critical situations and conflicts.

Content:

- Discussion of expectations, worries, uncertainties and recommendations with regard to the forthcoming company internship
- Assessment of personality profiles
- Reflection on own strengths and weaknesses
- Practicing various communication and conflict resolution techniques in group exercises and role-plays

Literature:
• HEDGE, Jason, 2012. *The Essential DISC Training Workbook: Companion to the DISC Profile Assessment*. ISBN 978-0615736396
Additional remarks:
None

Internship (18 weeks)

Module abbreviation:	CAI_Intshp	**SPO-No.:**	30
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	5
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	German	1 semester	only winter term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	25 ECTS / 0 SWS
Workload:	Contact hours: 0 h Self-study: 625 h Total effort: 625 h
Subjects of the module:	Internship (18 weeks) (CAI_Intshp)
Lecture types:	Pr - laboratory (CAI_Intshp)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

PrB - Internship report (CAI_Intshp)

Requirements:
None

Prerequisites according examination regulation:

All examinations of the first study section must have been passed and at least 20 credit points must have been achieved from modules of the first two semesters of the second study section.

Recommended prerequisites:

None

Objectives:

After attending the internship, students

- can apply scientific methods to real-world problems in the field of Computer Science and Artificial Intelligence.
- have consolidated their theoretical and practical knowledge and skills acquired in the previous study modules.
- are aware of the professional requirements that they will face when they start their career.
- know the basic elements of everyday business life.
- are able to successfully solve tasks or subtasks on their own responsibility, which are tailored to the progress of their studies.
- can contribute to the overall success as a member of a project team.
- are motivated to acquire not only specialist skills but also interdisciplinary skills.

During the internship, typical practical activities from the job profile of a computer scientist are to be deepened. Among others, this includes:

• designing information systems. • implementing information systems. • procuring, integrating and administering information systems. • testing of information systems.
Content:
• Selection of a suitable company as internship host in Germany or abroad • Participation in specific real-world professional tasks using the scientific methods learned • Producing a work plan for the internship with defined work packages to be worked on self-dependently • Preparation of an internship report
Literature:
No general literature is required.
Additional remarks:
None

Post-Internship Seminar

Module abbreviation:	CAI_PostS	**SPO-No.:**	31
Curriculum:	**Program**	**Module type**	**Semester**
	Computer Science and Artificial Intelligence (SPO WS 21/22)	Compulsory Subject	5
Modulattribute:	**Language of instruction**	**Duration of module**	**Frequency of offer**
	English	1 semester	winter and summer term

Responsible for module:	Windisch, Hans-Michael
Credit points / SWS:	2 ECTS / 1 SWS
Workload:	Contact hours: 12 h Self-study: 38 h Total effort: 50 h
Subjects of the module:	Post-Internship Seminar (CAI_PostS)
Lecture types:	S - seminar (CAI_PostS)
Usability for other study programs:	The possibility of crediting must be clarified with the head of the target program.

Examinations:

LN - participation without/with success (CAI_PostS)

Requirements:

To successfully complete the seminar, the students must work on and present a presentation (15 – 30 minutes).

Prerequisites according examination regulation:

All examinations of the first study section must have been passed and at least 20 credit points must have been achieved from modules of the first two semesters of the second study section.

Recommended prerequisites:

None

Objectives:

After successful participation in the course, the students are able:

- to reflect on their own practical experiences in relation to those of other students.
- to deepen and internalize their practical experience through moderated discussion, guidance and advice.
- to relate their practical experience with theoretical knowledge.
- to recognize that there is a variety of possible solutions to typical technical and methodological problems, from which the best is to be selected on a case-by-case basis.
- to objectively assess their presentation performance based on feedback from other participants.

Moreover, the course also helps participants to further strengthen their social skills.

Content:
• Introduction • Presentation of the topics in short papers (15 to 20 minutes each) • Discussion of the content and conclusions of the presentation directly afterwards • Immediate feedback to the speaker on his performance from the participants
Literature:
No general literature is required.
Additional remarks:
None

5.2 Elective Modules

The range of elective modules for the “Computer Science and Artificial Intelligence” program is revised every semester. In addition to suitable modules from related degree programs at THI, elective modules are also offered specifically for students of this program.

Possible topics for elective modules include:

- Robotics
- Autonomous Driving and Flying
- AI in Industry 4.0
- AI in the Life Sciences
- Mobile and Cloud Computing
- Data Protection in Cloud Computing
- Next Generation Networks
- Quantum Computing

and many more.