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PARIS LODRON UNIVERSITÄT SALZBURG

# Mitteilungsblatt – Sondernummer der Paris Lodron Universität Salzburg

## 112. Curriculum for the Master's Degree Programme in Computer Science at the Paris Lodron University of Salzburg

(Version 2023)

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In its session on 23.5.2023 the Paris Lodron University of Salzburg Senate formally approved the curriculum for the master's degree programme in Computer Science finalised by the Computer Science curriculum committee at the University of Salzburg in its 19.4.2023 meeting in the version that follows.

The legal basis for the curriculum is the 2002 Federal Act on the Organisation of Universities and their Studies (Universities Act 2002 – UG), Federal Law Gazette No. 120/2002, and the section of the Statutes of the University of Salzburg pertaining to university studies.

## § 1 General provisions

(1) The number of ECTS points necessary to complete a degree in the master's programme in Computer Science is 120. This corresponds to four semesters of study.

(2) Graduates of the master's programme in Computer Science hold a Diplom-Ingenieur/in degree (Dipl.-Ing. or DI).

(3) In order to be admitted to the master's programme in Computer Science, students must hold a bachelor's degree in an equivalent or related field from a recognized domestic or foreign university or post-secondary educational institution (see UG2002 §64 para. 3).

(4) If a student's bachelor's degree is not deemed equivalent to an acceptable extent, the student may be required to complete additional work worth up to 45 ECTS points; these requirements must be satisfied by the end of the master's programme. Only the Rectorate or a member of staff at the University of Salzburg designated by the Rectorate is authorised to make a determination of equivalency and thus a student will be admitted.

(5) The selection of candidates for the Computer Science master's programme is made on the basis of the application supporting documents. A detailed description of the process can be found in the Annex IV: Application procedure.

(6) Students holding one of the following degrees from the University of Salzburg are unconditionally accepted: BA Informatik, BA Lehramt: Unterrichtsfach Informatik und Informatikmanagement.

(7) All graduation requirements to be fulfilled by students have been assigned ECTS points. One ECTS point equals 25 hours of study, which corresponds to the average number of hours required to achieve the expected learning objectives. An academic year consists of 1500 hours, corresponding to 60 ECTS points.

(8) Students with disabilities and/or chronic illnesses will not be subject to any form of discrimination in their studies. The University is committed to the basic principles laid out in the UN Convention on the Rights of Persons with Disabilities and Austrian non-discrimination laws as well as the policy of positive action.

(9) Examinations for all mandatory classes in this program can be taken in English. Students may also take courses in German offered as equivalent to the courses taught in English.

## § 2 Overview of the degree programme and professional skills

### (1) Overview of the degree programme

The master's programme in Computer Science serves to deepen and expand competencies in the field of computer science and its application areas.

The compulsory modules teach current methods and techniques in important core areas such as advanced Algorithms and Data Structures, IT security or distributed systems based on scientific findings. Furthermore, enhanced competences are acquired, whereby the focus can optionally be placed on formal (e.g., Advanced Mathematics, Theoretical Computer Science) or practically motivated (e.g., Databases, Software Techniques, Software Systems) subjects.

The elective modules cover application areas and advanced or complementary subjects of computer science, whereby an individual focus is possible. Application modules provide an overview of the respective application area combined with specific knowledge of computer science for the processing of typical problems in the area. Application areas include geoinformatics, bioinformatics, information law, multimedia, image processing, data analysis and geometric computing. Elective modules include advanced or complementary subjects, which can be composed from the current range of courses.

### (2) Professional skills and competencies (Learning Outcomes)

Graduates of the master's program in computer science have in-depth knowledge in the core areas of computer science. They are able to apply their knowledge and skills that enable flexible use in various professional fields and enable targeted innovations in computer science.

The knowledge of theoretical foundations and current facts is the basis for innovative solutions in the creation, application and further development of complex systems and forms the prerequisite for targeted research. As a result, graduates also possess a critical awareness of the application and impact of various technologies.

Graduates possess various skills in the application of current methods and techniques, which enable problem-oriented solutions and the (further) development of new procedures on questions of computer science and its diverse fields of application.

Graduates of this master's program can work independently on complex problems and are able to design and manage corresponding projects.

The program is scientifically based and teaches different working methods, which also provides the basis for further relevant research, such as a corresponding doctoral program.

### (3) Importance and relevance of the degree for society, the scientific community and the labour market

Graduates of the master's program in computer science can be employed in many areas of designing, developing, expanding, and supporting complex IT systems. This refers to public administration as well as to companies with different fields of activity.

Graduates of the master's program in Computer Science often pursue careers in the following fields:

- Development of software and hardware systems
- Management of IT departments
- Conception and management of projects in the IT sector
- Consulting in the IT sector
- Training courses

## § 3 Structure of the programme

The master's program in Computer Science comprises 7 modules with a total number of 79 ECTS points. In addition, there are 6 ECTS points assigned for free elective courses. The master's thesis is worth 30 ECTS points and the master's exam is worth 5 ECTS points

| | ECTS |
|---|---|
| Compulsory Modules | 39 |
| Elective Modules | 40 |
| Free elective courses | 6 |
| Master's thesis | 30 |
| Master's exam | 5 |
| **Total** | **120** |

## § 4 Course Types

The programme contains the following course types:

**Lecture courses (VO)** provide an overview of an area or subarea as well as the theoretical approaches to it and present various methods and points of view. The content is communicated primarily in lecture format. A lecture course does not carry mandatory attendance.

**Proseminars (PS)** stand between exercises and seminars and contain elements of both: practicing the application of computer science skills is combined with discussion and reflection on scientific themes. Proseminars carry mandatory attendance.

**Exercises with lectures (UV)** combine a theoretical introduction into a subarea with the communication of practical skills. However, here the emphasis on practical skills dominates. Exercises with lectures carry mandatory attendance.

**Lectures with exercises (VU)** combine a theoretical introduction into a subarea with the communication of practical skills. Lectures with exercises do not carry mandatory attendance.

**Seminars (SE)** are courses leading deeper into a focused subject matter. They serve the acquisition of deeper specialized knowledge and the capacity for discussion and reflection on scientific themes, usually in the context of collaborative learning on the part of the student. Seminars carry mandatory attendance.

Through the choice of free electives, also other course types may apply. They are explained in their respective home curriculum.

## § 5 Required courses and plan of study

The following contains a list of modules and courses in the master's programme in Computer Science. The division into semesters serves as a recommendation designed to ensure that the order in which the courses are taken builds on knowledge acquired successively and that the workload of 60 ECTS points in an academic year is not exceeded. Modules and courses can however be taken in a different order.

Detailed descriptions of the modules including the knowledge, methods, and skills to be acquired can be found in Annex I: Module descriptions of mandatory modules.

| **Master's degree programme in Computer Science** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Module** | **Course** | **SHrs** | **Type** | **ECTS** | **Semester with ECTS** | | | |
| | | | | | **I** | **II** | **III** | **IV** |
| **(1) Compulsory modules** | | | | | | | | |
| The compulsory modules listed must be combined in such a way that a total of 39 ECTS points is completed. | | | | | | | | |
| **P1: Advanced Formal Techniques (Theory in Depth)** | | | | | | | | |
| courses in the range of 10 to 18 ECTS points must be chosen | | | | | | | | |
| Advanced Mathematics for Computer Science | | 3 | VO | 3 | 3 | | | |
| Advanced Mathematics for Computer Science | | 2 | PS | 4 | 4 | | | |
| Theoretical Computer Science | | 3 | VO | 3 | | 3 | | |
| Theoretical Computer Science | | 2 | PS | 4 | | 4 | | |
| Advanced Algorithms and Data Structures | | 3 | VO | 3 | 3 | | | |
| Advanced Algorithms and Data Structures | | 2 | PS | 4 | 4 | | | |
| | | | | | | | | |
| **P2: Software in Depth** | | | | | | | | |
| courses in the range of 8 to 13 ECTS points must be chosen | | | | | | | | |
| Advanced Data Bases | | 2 | VO | 2 | 2 | | | |
| Advanced Data Bases | | 1 | PS | 2 | 2 | | | |
| Software Techniques | | 2 | VO | 2 | | 2 | | |
| Software Techniques | | 1 | PS | 2 | | 2 | | |
| Seminar in Computer Science | | 2 | SE | 5 | | 5 | | |
| | | | | | | | | |
| **P3: Software Systems** | | | | | | | | |
| courses in the range of 12 to 16 ECTS points must be chosen | | | | | | | | |
| Enterprise Computing | | 2 | UV | 4 | 4 | | | |
| Distributed Systems | | 2 | VO | 2 | 2 | | | |
| Distributed Systems | | 1 | PS | 2 | 2 | | | |
| IT-Security | | 2 | VO | 2 | 2 | | | |
| IT-Security | | 1 | PS | 2 | 2 | | | |
| Advanced Systems Engineering | | 3 | UV | 4 | | 4 | | |
| | | | | | | | | |
| Total for Compulsory Modules | | | | **39** | 26 | 13 | | |
| | | | | | | | | |
| **(2) Elective modules according to § 6** | | | | | | | | |
| Selection of elective modules of 40 ECTS points according to § 6 | | | | 40 | 4 | 16 | 20 | |
| Total for Elective Module Catalogues | | | | **40** | 4 | 16 | 20 | |
| | | | | | | | | |
| **(3) Free elective courses** | | | | **6** | | 1 | 5 | |
| | | | | | | | | |
| **(4) Master's thesis** | | | | **30** | | | 5 | 25 |
| | | | | | | | | |
| **(5) Master's exam** | | | | **5** | | | | 5 |
| | | | | | | | | |
| Sum total | | | | **120** | 60 | | 60 | |

## § 6 Elective module catalogues and/or bundled elective modules

(1) In the master's programme in Computer Science, students are to complete elective modules totalling 40 ECTS points. The list of elective modules can be found in Annex II: Module descriptions of elective modules.

(2) If selected elective modules show a slight deviation from the 10 ECTS credits provided in each case, this difference must be compensated for within the framework of the elective modules.

## § 7 Free elective courses

(1) In the master's programme in Computer Science, students are to complete free elective courses totalling 6 ECTS points. These free elective courses are designed to further the acquisition of additional professional skills and strengthen individual areas of focus within a student's course of study. They can be completed at any accredited postsecondary institution.

## § 8 Master's thesis

(1) The master's thesis serves to demonstrate that students have acquired the ability to perform independent academic research in the area of Computer Science according to current academic research methods and standards.

(2) The topic of the master's thesis should be chosen in such a way that it is reasonable and appropriate for completion of the thesis within six months (cf. UG2002 §81 para. 2).

(3) The topic of the master's thesis must be taken from a module in the master's curriculum. The student may suggest a topic or choose from a number of topics provided by one of the available thesis advisors.

(4) It is to be noted that both the student's work on the topic and advisor's work with the student are governed by Austrian copyright law, Federal Law Gazette No. 111/1936 (cf. UG2002 §80 para. 2).

## § 9 Recommended internship

It is recommended that, as part of the free elective requirement, students complete a professionally oriented internship comprising 4 weeks, which is comparable to full-time employment (this corresponds 6 ECTS points). The internship must have a reasonable connection to the degree programme and must be approved by the responsible body before the internship is scheduled to begin.

## § 10 Study abroad

Students in the master's programme in Computer Science are recommended to spend a semester of study abroad. This semester abroad should ideally be scheduled in the second to third semester of study. Course transfers for the courses completed at the university abroad will be granted by the responsible body. Documents needed for the assessment of transfer courses are to be provided by the student.

Steps will be taken to ensure that the semester abroad can be completed without causing a delay in a student's course of study when the following conditions are met:

- at least 30 ECTS credits are earned in each semester of study abroad

- the content of the courses completed during the period of study abroad is not identical to courses already completed at the University of Salzburg
- confirmation by formal notification in writing before beginning the study abroad period of which courses and/or exams planned to be taken abroad are transferable to the University of Salzburg

In addition to field-specific knowledge and skills, students stand to gain the following qualifications by studying abroad:

- acquisition and consolidation of field-specific knowledge in a foreign language
- acquisition and consolidation of general foreign-language skills (comprehension, conversation, etc.)
- acquisition and consolidation of organisational skills gained by independently navigating the bureaucracy and organisational structure of a university abroad as well as daily challenges of student life abroad
- becoming acquainted with international student exchange programmes and broadening one's perspectives in one's own field of study
- acquisition and consolidation of intercultural communication skills

Students with disabilities and/or chronic illnesses will be assisted in their search for a study abroad opportunity and in planning for their semester abroad by the Office of the Rectorate for Family, Gender, Disability & Diversity.

## § 11 Allocation of places in courses with a limited number of participants

(1) The maximum number of participants in the master's programme in Computer Science for the following course types is limited as follows:

| | |
|---|---|
| Lectures (VO) | no limit |
| Lectures with exercises (VU) | no limit |
| Proseminars (PS) | 25 |
| Exercises with lectures (UV) | 25 |
| Seminars (SE) | 15 |

(2) In instances in which courses with a restricted number of participants are oversubscribed, priority of enrolment will be given to students for whom the course is part of the curriculum.

(3) Students in the master's programme in Computer Science will be given places in courses based on the total number of ECTS credits they have earned in the programme so far. If multiple students registering for a particular course have earned the same number of ECTS credits, the available places in this course will be allocated based on the following criteria in the order listed below:

- a student was on the waiting list in the course in the previous academic year
- a student has completed a greater number of courses and/or exams
- a student has completed a greater number of semesters in the programme of study
- average grading score weighted according to ECTS credit
- random selection

Available places will be allocated to students from other programmes using the same criteria in the same order.

(4) For students participating in international exchange programmes, additional places constituting at least ten percent of the maximum number of participants in each course will be made available. These places will be allocated randomly.

## § 12 Examination regulations

(1) Courses will be graded by the instructor. A module counts as completed when the required number of ECTS points have been earned. The evaluation of the whole module is determined based on the grades for the courses that compose it. It is calculated in accordance with the number of credits assigned to the courses (see Satzung der Universität Salzburg, I. Teil: Studienrecht § 19 (3)). The final grade for each module will be recorded in the certificate of completion of the master's exam.

(2) The master's programme is considered finished when

- all compulsory modules, all selected elective modules and the free elective courses have been successfully completed.
- the master's thesis has been accepted, and
- the commissional master's exam (see §13) has been passed.

## § 13 Master's examination before examining committee

(1) The master's programme in Computer Science concludes with a master's examination worth 5 ECTS credits before an examining committee.

(2) Students must have successfully completed all the required courses and the master's thesis to be eligible to take the master's examination.

(3) The master's examination consists of three parts of approximately equal weight. The first one will be a presentation of the master's thesis with discussion (at most 20 minutes). The second and third ones will be about two different scientific areas of Computer Science which are not identical with the area of the master's thesis but may have a relation to it. These two scientific areas can be suggested by the student and are subject to approval by the curricular committee.

## § 14 Effective date

The curriculum comes into force 1 October 2023.

## § 15 Transitional provisions

(1) Students enrolled in the curriculum for the master's programme of study in Computer Science at Paris Lodron University of Salzburg in the 2016 version (Mitteilungsblatt – Sondernummer 60, 4.2.2016) when this curriculum comes into force have to complete the programme in which they are enrolled until 30.9.2025.

(2) Students subject to a different curriculum may during any period of registration decide to change into this curriculum. An irrevocable written declaration is to be submitted to the Office of Admissions (Studienabteilung), should a student wish to change curricula.

(3) Annex III contains a course equivalency list in comparison with the 2016 version.

## Annex I: Module descriptions of Mandatory Modules

| Module description | **Advanced Formal Techniques (Theory in Depth)** |
|---|---|
| Module code | P1 |
| Total workload | 10 to 18 ECTS |
| Learning outcomes | Subject competence: Knowledge of in-depth theoretical and formal basics of computer science, depending on the chosen field, and the ability to formulate and explain them in a comprehensible way.<br>Methodological and practical competence: Ability to apply the acquired knowledge to deal with problems theoretically (e.g., solving formal problems) and practically (e.g., designing algorithms, implementing them in software).<br>Critical judgement competence: Assessment of formal and theoretical basics of computer science as well as targeted use of these in application areas. |
| Module content | Advanced Mathematics for Computer Science: Fourier theory and practice, differential equations.<br>Theoretical Computer Science: in-depth contents from computability, complexity, logic, formal speech, automata theory, ...<br>Advanced Algorithms and Data Structures: special algorithms and data structures (e.g., randomized algorithms) and their complexity and termination. |
| Courses | Choice of courses from 11 to 18 ECTS:<br>Advanced Mathematics for Computer Science (3 SHrs., VO, 3 ECTS)<br>Advanced Mathematics for Computer Science (2 SHrs., PS, 4 ECTS)<br>Theoretical Computer Science (3 SHrs., VO, 3 ECTS)<br>Theoretical Computer Science (2 SHrs., PS, 4 ECTS)<br>Advanced Algorithms and Data Structures (3 SHrs., VO, 3 ECTS)<br>Advanced Algorithms and Data Structures (2 SHrs., PS, 4 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Software in Depth** |
|---|---|
| Module code | P2 |
| Total workload | 8 to 13 ECTS |
| Learning outcomes | Subject competence: Knowledge of advanced and special methods in the areas of databases and software techniques or to obtain an overview of current procedures.<br>Methodological and practical competence: Ability to independently select the acquired techniques and to combine them with other methods to create and integrate target-oriented systems.<br>Critical judgement competence: Assessment of different techniques for their applicability to specific problems and software solutions, including the assessment of effects, e.g., when integrating them into other IT systems. |
| Module content | Advanced Data Bases: in-depth understanding of the techniques, algorithms and data structures used to implement database systems.<br>Software Techniques: programming methodology, systematic design, adequate modularization.<br>Seminar for Computer Science: familiarization with a special topic, giving a lecture on it and preparing a written paper. |
| Courses | Choice of courses from 8 to 13 ECTS:<br>Advanced Data Bases (2 SHrs., VO, 2 ECTS)<br>Advanced Data Bases (1 SHrs., PS, 2 ECTS)<br>Software Techniques (2 SHrs., VO, 2 ECTS)<br>Software Techniques (1 SHrs., PS, 2 ECTS)<br>Seminar in Computer Science (2 SHrs., SE, 5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Software Systems** |
|---|---|
| Module code | P3 |
| Total workload | 12 to 16 ECTS |
| Learning outcomes | Subject competence: Knowledge of advanced and special methods in the areas of enterprise computing, IT security s and distributed software systems and to obtain an overview of current procedures.<br>Methodological and practical competence: Ability to independently select the acquired techniques and to combine them with other methods in order to create and integrate target-oriented systems.<br>Critical judgement competence: Assessment of different techniques for their applicability to specific problems and software solutions, including the assessment of effects, e.g., when integrating them into other IT systems. |
| Module content | Enterprise Computing: large-scale software applications for visualizing, manipulating and storing large amounts of often complex data for support and automation of business processes in large organizations.<br>Distributed Systems: concepts and terms of distributed and parallel systems, protocols, synchronization.<br>IT Security: various aspects of IT security, such as risks of and mitigations against attacks targeting networks, operating systems, software components, etc.<br>Advanced Systems Engineering: advanced concepts for operating systems |
| Courses | Choice of courses from 12 to 16 ECTS:<br>Enterprise Computing (2 SHrs., UV, 4 ECTS)<br>Distributed Systems (2 SHrs., VO, 2 ECTS)<br>Distributed Systems (1 SHrs., PS, 2 ECTS)<br>IT-Security (2 SHrs., VO, 2 ECTS)<br>IT-Security (1 SHrs., PS, 2 ECTS)<br>Advanced Systems Engineering (3 SHrs., UV, 4 ECTS) |
| Type of exam | Individual exams per course |

## Annex II: Module descriptions of Elective Modules

The following listing is in alphabetical order with the individual elective modules at the end:

| Module description | **Advanced Software Engineering** |
|---|---|
| Module code | EM1 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of selected current topics of complex software systems, especially in the area of embedded and cyber-physical systems, and skills for an engineering approach to their development.<br>Methodological and practical competence: Knowledge of procedures and methods in software development, which allow the reflection of existing software solutions and the development of own ones, as well as the general ability to apply the acquired knowledge to solve problems.<br>Critical judgement competence: Ability to arrive at an independent, well-founded assessment of development processes, tools and programming paradigms in order to meet functional and non-functional requirements, taking into account given resources. |
| dule content | Modeling, analysis, design, simulation and verification of software systems, in-depth content from software testing, agile vs. conventional software development process, selected current tools in software development, aspects of special software systems such as Internet applications or embedded systems. |
| Courses | Model-based Software Design (3 SHrs., UV, 5 ECTS)<br>Selected Topics in Software Engineering (3 SHrs., UV, 5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Bioinformatics** |
|---|---|
| Module code | EM2 |
| Total workload | 9 - 12 ECTS |
| Learning outcomes | Subject competence: Understanding of central concepts and issues in bioinformatics and an overview of their methods and solution approaches.<br>Methodological and practical competence: Ability to apply and implement bioinformatics methods to relevant problems.<br>Critical judgement competence: Recognize applicability and limitations of bioinformatics methods and interpret results of corresponding tools. |
| Module content | Core areas of bioinformatics such as sequences and spatial structures of genes and proteins, core mathematical and information theoretic tools, effective search in molecular databases. |
| Courses | (Some courses can be in German)<br>Genetik (2 SHrs., VO, 3 ECTS)<br>Allgemeine Biologie (1 SHrs., VO, 1.5 ECTS)<br><br>Choice of courses in the amount of 4.5 - 7.5 ECTS from:<br>Bioinformatik (2 SHrs., VO, 3 ECTS)<br>Bioinformatik II (2 SHrs., UE, 2 ECTS)<br>Digitalisierung (1 SHrs., VO, 1.5 ECTS)<br>Biomedical Data - from molecules to diseases (1 SHrs., VO, 1.5 ECTS)<br>Hands-on biomedical data (3 SHrs., UE, 4.5 ECTS)<br>Big data management (1 SHrs., VO, 1.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Concurrency and Verification** |
|---|---|
| Module code | EM3 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Students learn the advantages and disadvantages of concurrent programs and processes. In particular, they gain the experience that precise semantics is especially necessary in this area. They are able to develop concurrent algorithms and systems and to argue about their correctness.<br>Methodological and practical competence: Independent development of correct concurrent software systems. With the help of the corresponding theory, verification tools can be applied, understood and developed.<br>Critical judgment competence: Ability to evaluate and compare different development principles and verification methods for concurrent programs. |
| Module content | Introduction to Concurrency Theory and Practice: different approaches to concurrency from algorithms to formal semantics. Methods for checking correctness.<br>Computer Aided Verification: various automatic or semi-automatic verification methods, including model checking, testing, theorem proving, process algebra.<br>Coalgebra: This course introduces the basics, but also some research-close topics, of the theory of coalgebra (a relatively new area in formal methods) which is a unifying theory for different kinds of transition systems, automata, and their semantics, based on category theory. |
| Courses | Selection of courses to the extent of 10 ECTS:<br>Concurrency Theory and Practice (2 SHrs., VO, 2.5 ECTS)<br>Concurrency Theory and Practice (1 SHrs., PS, 2.5 ECTS)<br>Computer Aided Verification (2 SHrs., VO, 2.5 ECTS)<br>Computer Aided Verification (1 SHrs., PS, 2.5 ECTS)<br>Coalgebra (3 SSt, VU, 5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Data Analysis** |
|---|---|
| Module code | EM4 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of advanced techniques in pattern recognition and machine learning, in particular their theoretical foundations and the derivation of efficient algorithms in these areas. Knowledge of important libraries and software systems in these areas.<br>Methodological and practical competence: Ability to use the acquired knowledge to independently develop software to solve problems. Competence to select suitable libraries and/or software systems in order to solve practical problems with minimal self-implementation effort.<br>Critical judgement competence: Assessment of practical problems in the field of machine learning and pattern recognition with regard to their treatability from an algorithmic and software-technical point of view, ability to assess computational complexity and selection of appropriate hardware. |
| Module content | Classical classification methods, advanced artificial intelligence methods such as genetic algorithms and neural networks, boosting, kernel methods, decision trees, clustering methods, dimensionality reduction, decision ensembles. |
| Courses | Pattern Recognition 1 (2 SHrs., UV, 2.5 ECTS)<br>Pattern Recognition 2 (2 SHrs., UV, 2.5 ECTS)<br>Statistical Learning Theory (2 SHrs., VO, 2.5 ECTS)<br>Statistical Learning Theory (1 SHrs.,, PS, 2.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Data Management** |
|---|---|
| Module code | EM5 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of advanced techniques for storing, managing and querying data, critical understanding of the problems of large data volumes and complex queries, as well as an overview of the state of the art and current challenges in the field of databases.<br>Methodological and practical competence: Ability to independently design innovative systems for data management from scratch, as well as to select existing systems according to specific requirements and to use them in a professional manner.<br>Critical judgement competence: Assessment of data management systems with regard to their possibilities and limitations for specific requirements, assessment of the effects of advanced data management systems for the development of information technology, new services and the organizational structure of companies. |
| Module content | Similarity Search in Large Databases: basics of similarity queries, similarity measures, filtering techniques, set-based and metric search techniques, index structures for fuzzy predicates.<br>Parallel and Distributed Data Management: Database system architectures, parallel and distributed data storage, parallel query processing, commit protocols, distributed concurrency control, availability, NoSQL databases, databases on modern hardware, databases for special applications. |
| Courses | Similarity Search in Large Databases (3 SHrs., UV, 5 ECTS)<br>Parallel and Distributed Data Management (3 SHrs., UV, 5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Geographic Information Systems and Science** |
|---|---|
| Module code | EM6 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge and understanding of important terms and basics of geographic information systems.<br>Methodological and practical competence: Efficiently apply appropriate methods and techniques or implement them by means of informatic procedures.<br>Critical judgement competence: Assessment and classification of special procedures and solutions, also recognition of their limits or possibilities of further development. |
| Module content | Basic concepts and procedures of Geographic Information Systems. |
| Courses | One ESRI campus online course (1 ECTS)<br>(recommended:<br>ESRI VC Understanding Geographic Data<br>ESRI VC Spatial Referencing)<br>Location Based Services and Systems (6 ECTS)<br>(realized at the moment:<br>Mobile und standortbezogene Anwendungen (3 ECTS)<br>Big Data analytics (3 ECTS))<br>Design of Geospatial Data Models (3 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Geometric Computing** |
|---|---|
| Module code | EM7 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of geometric algorithms and the ability to formulate and explain them in a comprehensible manner.<br>Methodological and practical competence: Ability to apply the acquired knowledge to deal with problems theoretically (e.g., solving geometric |

| | |
|---|---|
| | problems) and practically (e.g., designing algorithms, implementing them in software).<br>Critical judgement competence: Assessment of geometric algorithms and their formal and theoretical foundations as well as targeted use of these in application areas. |
| Module content | Computational Geometry: Algorithms, concepts and applications of algorithmic geometry, for example geometric search, convex hulls, Voronoi diagram, skeletal structures, triangulations, robustness of geometric algorithms.<br>Geometric Modeling: Algorithms, concepts and applications of geometric modeling, for example Bezier curves, B-splines and NURBs, differential geometry of curves and surfaces. |
| Courses | Computational Geometry (2 SHrs., VO, 2.5 ECTS)<br>Computational Geometry (1 SHrs., PS, 2.5 ECTS)<br>Geometric Modeling (2 SHrs., VO, 2.5 ECTS)<br>Geometric Modeling (1 SHrs., PS, 2.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Human-Computer Interaction** |
|---|---|
| Module code | EM8 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge and understanding of the significance, principles and central approaches of the interdisciplinary field of Human-Computer Interaction, developing HCI-oriented thinking strategies and designing solutions for different contexts.<br>Methodological and practical competence: Getting to know the basic interdisciplinary methods and tools of the field and developing them further in an application-oriented manner, ability to apply the acquired knowledge to theoretical scientific questions as complex practical problems.<br>Critical judgement competence: Critical assessment of technological and methodological approaches and solutions from an HCI point of view, corresponding reflexion and development of well-founded optimization potentials. |
| Module content | HCI Theory & Paradigms: this course provides a comprehensive overview of theories and paradigms of HCI. Starting with a historical overview of HCI research, it focuses on depicting and discussing modern HCI theories (i.e. situated action) as well as contemporary trends and paradigms, such as values in HCI, the role of design, or embodiment.<br>Foundations of HCI Methodologies: this course covers a broad range HCI research and design-oriented methodologies such as user-centred design, human-centred design, research through design, research by design, research for design, experience-centred design, participatory design, critical design, or reflection in action. It covers different forms of research questions in HCI and how these questions can be answered by HCI methodologies.<br>Human Factors & Design Principles: this course covers basics and new approaches in human factors, software and hardware ergonomics, understanding different aspect of the human and design principles triggered by this. The course emphasizes individual human factors (e.g., perception, cognition, motor control, anthropometry) as well as the organizational arrangements that can amplify or correct human factors' problems or lead to human error. It includes HCI related models such as Fitts' law.<br>Experience Engineering Methods: this course provides a systematic introduction to usability and experience engineering methods and processes. It starts with an introduction to overall approaches in the context of an engineering process and how they are applied to HCI problems. The course will focus on the basics of requirements engineering and analysis activities (e.g., contextual inquiry, task analysis, |

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|---|---|
| | ethnography, observation), conceptual design as well as analytical and empirical evaluation methods and measurements (e.g., heuristic evaluation, A/B testing, usability studies, physiological measurements).<br>Interaction Design: this course will start with an introduction to the basics of interaction design and the cognitive processes that underlie interaction. It then will tackle the design of the interactions between users and interactive systems and how to develop interaction designs for a given HCI problem. The combination of different interaction modalities and the application of appropriate interaction design principles and approaches are practiced on the basis of guided examples.<br>Contextual Analysis & Context Capturing: this course covers different context definitions and models and how to select and apply methods to gather requirements specific for different and complex application areas. In this course students will be confronted with contextual challenges in various application areas (e.g., automotive, factory, hospital, home). The preparation and execution of analyses in these different application areas is practiced as well as the interpretation of collected data and the formulation of contextual requirements. Students will also learn to draw conclusions for follow up development stages.<br>Contextual Interaction Design: this course leads the students to conceptualize, design and implement experience prototypes for interaction problems in specific application areas and evaluate these designs in experiments and user studies. The translation of complex contextual requirements into concrete designs and implementations is practiced. |
| Courses | Selection of courses to the extent of 10 ECTS:<br>HCI Theory & Paradigms (2 ECTS)<br>Foundations of HCI Methodologies (4 ECTS)<br>Human Factors & Design Principles (2 ECTS)<br>Experience Engineering Methods (4 ECTS)<br>Interaction Design (3 ECTS)<br>Contextual Analysis & Context Capturing (3 ECTS)<br>Contextual Interaction Design (3 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Image Processing** |
|---|---|
| Module code | EM9 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge and understanding of standard and advanced algorithms of machine vision, as well as selected medical imaging methods and 3D sensor technology, and the ability to formulate and explain these in a comprehensible manner.<br>Methodological and practical competence: Ability to apply the acquired knowledge theoretically and practically (e.g., design of algorithms, implementation in software).<br>Critical judgement competence: Assessment of algorithms of machine vision with regard to their theoretical foundations, as well as targeted use of these in various problems and application areas. |
| Module content | Imaging Beyond Consumer Cameras: Algorithms, concepts and applications from the fields of 3D imaging techniques, such as stereo vision, time-of-flight, structured light etc.<br>Medical Imaging: Algorithms, concepts and applications from the fields of medical imaging such as X-ray, magnetic resonance imaging, computed tomography, etc. |
| Courses | Imaging beyond Consumer Cameras (2 SHrs., VO, 2.5 ECTS)<br>Imaging beyond Consumer Cameras (1 SHrs., PS, 2.5 ECTS)<br>Medical Imaging (2 SHrs., VO, 2.5 ECTS)<br>Medical Imaging (1 SHrs., PS, 2.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Information Law** |
|---|---|
| Module code | EM10 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Understanding knowledge of important terms and principles from relevant areas of law.<br>Methodological and practical competence: Acquire skills and knowledge to be able to independently deal with current issues in connection with IT law.<br>Critical judgement competence: To be able to assess current problems and questions within the framework of IT law and to classify them legally. |
| Module content | Teaching of basic knowledge from various fields of law with application or reference to information technology, also on the basis of case studies. |
| Courses | Choice of courses in the amount of 10 ECTS from (courses are taught in German):<br>IT-Recht und Legal Tech (2 SHrs., SE, 5 ECTS)<br>Computer- und Online Strafrecht (1 SHrs., UV, 2 ECTS)<br>Privates Informatikrecht (2 SHrs., VO, 3 ECTS)<br>Datenschutz und E-Government (2 SHrs., VU, 3 ECTS)<br>Datenbankrecherche (2 SHrs., UV, 4 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Multimedia and Security** |
|---|---|
| Module code | EM11 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of advanced issues, techniques and methodologies in multimedia and security and biometrics. Algorithmic, theoretical and system knowledge with a focus on security issues of visual data and visual biometric modalities.<br>Methodological and practical competence: Ability to use the acquired knowledge to independently develop software to solve problems. Competence to identify security-critical issues and problem areas in the field of multimedia and to be able to secure them in the long term, either by developing one's own software or by using third-party software.<br>Critical judgement competence: Ability to judge biometric system requirements and their critical parts. Ability to evaluate critical elements and weak points in the safeguarding of multimedia application systems and to assess the corresponding possible solutions. |
| Module content | Basic issues and approaches of media security and the differences to classical cryptography, media encryption, information hiding (watermarking, steganography, integrity protection of media data by water lines), robust hashing, digital forensics, requirements for biometric systems and their performance parameters, fingerprint recognition, iris recognition, face recognition, vein recognition, voice and signature recognition, security of biometric systems. |
| Courses | Multimedia Security (2 SHrs., VO, 2.5 ECTS)<br>Multimedia Security (1 SHrs., PS, 2.5 ECTS)<br>Biometric Systems (2 SHrs., VO, 2.5 ECTS)<br>Biometric Systems (1 SHrs., PS, 2.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Multimedia in Practice** |
|---|---|
| Module code | EM12 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of various methods of editing and integrating multimedia and web-based content, knowledge of the advantages and disadvantages of various software systems for this purpose, as well as of the state of the art in the field of the corresponding publication and |

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| | presentation options.<br>Methodological and practical competence: Ability to independently select suitable software systems and to use them for the processing and integration of multimedia and web-based content. The goal is the competence to create multimedia and web-based publications and presentations.<br>Critical judgment competence: Evaluation of software products for editing multimedia and web-based content and ability to analyze practical tasks in order to select the appropriate tools according to the application requirements.. |
| Module content | Software for image and video editing, video editing systems, tools for audio processing, scripting languages for dynamic creation of web content, creation of multimedia publications and presentations. |
| Courses | Webprogrammierung (2 SHrs., UV, 3 ECTS)<br>Web Projekt (1 SHrs., UV, 3 ECTS)<br>Courses from Studienergänzung „Digitale Medien“ in the extent of 4 ECTS |
| Type of exam | Individual exams per course |

| Module description | **Multimedia Technologies** |
|---|---|
| Module code | EM13 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of in-depth theoretical, formal, algorithmic and practical fundamentals and application areas in the field of multimedia technologies, critical understanding of the problems of the interplay between hardware and software in this field, as well as an overview of the state of the art and current challenges.<br>Methodological and practical competence: Ability to use the acquired knowledge for the independent development of software to solve problems. Competence to analyze requirements of multimedia technologies and to select suitable hardware and software configurations for their processing. Ability to scientifically process and write down the results achieved.<br>Critical judgement competence: Assessment of practical problems in the area of multimedia technologies with regard to the resources to be used in the hardware and software area in order to be able to solve them efficiently under various restrictions. |
| Module content | Audio Processing: Fourier transform, basic audio processing, noise reduction, audio compression, audio formats, media processors, DSPs<br>Computer Vision: Algorithms, concepts and applications of machine vision, such as stereo vision, object recognition, object classification, etc.<br>Multimedia Technologies: multimedia applications, current literature in multimedia technologies. |
| Courses | Choice of courses with 10ECTS:<br>Audio Processing (2 SHrs., VO, 2.5 ECTS)<br>Audio Processing (1 SHrs., PS, 2.5 ECTS)<br>Computer Vision (2 SHrs., VO, 2.5 ECTS)<br>Computer Vision (1 SHrs., PS, 2.5 ECTS)<br><br>Seminar Multimedia Technologien (1 SHrs., SE, 2.5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Parallel and Distributed Algorithms and Programming** |
|---|---|
| Module code | EM14 |
| Total workload | 10 ECTS |
| Learning outcomes | Subject competence: Knowledge of distributed and parallel models and algorithms, fundamental concurrency issues related to them, and practical programming aspects. |

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| | Methodological and practical competence: Ability to apply the acquired knowledge to deal with problems theoretically (e.g., solving computational problems) and practically (e.g., designing algorithms, implementing them in software).<br>Critical judgment competence: Assessment of parallel and distributed algorithms and their formal and theoretical foundations as well as targeted use of these in application areas. |
| Module content | Parallel and distributed processing models with shared or distributed memory like SIMD, MIMD, SPMD, PRAM, LOCAL, CONGEST, GOSSIP, MPC.<br>Distributed and parallel algorithms for fundamental tasks like counting, sorting, leader election, graph problems, and rumor spreading.<br>Fundamental concurrency issues like mutual exclusion, concurrent objects, primitive synchronization operations, and universality.<br>Practial programming aspects for implementing algorithms like spin locks and contention, monitors, parallel data structures, the Message Passing Interface (MPI), and graph processing systems. |
| Courses | Selection of courses to the extent of 10 ECTS:<br>Distributed Algorithms (3 SHrs., UV, 5 ECTS)<br>Parallel Algorithms (2 SHrs., VO, 2.5 ECTS)<br>Parallel Algorithms (1 SHrs., PS, 2.5 ECTS)<br>Parallel Programming (3 SHrs., UV, 5 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Remote Sensing** |
|---|---|
| Module code | EM15 |
| Total workload | 9 to 12 ECTS |
| Learning outcomes | Subject Competence: Knowledge and understanding of the basics of remote sensing, especially as a source of geodata.<br>Methodological and practical competence: Apply appropriate methods and techniques, especially image processing and classification, in a targeted and efficient manner.<br>Critical judgement competence: Assessment of remote sensing methods for their applicability to corresponding problems and implementation with informatic methods. |
| Module content | Basic concepts and procedures of remote sensing, typical work steps such as data acquisition, processing, analysis and application. |
| Courses | Choice of courses from 9 to 12 ECTS:<br>Remote Sensing and Image Processing (3 ECTS)<br>Advanced Remote Sensing (6 ECTS)<br>Object-based Image Analysis (3 ECTS) |
| Type of exam | Individual exams per course |

| Module description | **Individual Elective Module A** |
|---|---|
| Module code | IMA |
| Total workload | 6 to 15 ECTS |
| Learning outcomes | Subject competence: knowledge and deepening of central concepts and procedures combined with special extensions of the chosen subjects master and understand.<br>Methodological and practical competence: extended ability to independently and objectively apply in-depth methods to solve relevant problems in the chosen subjects.<br>Critical judgment competence: Assessment of concepts and procedures with regard to their applicability to specific problems, including the associated effects, and recognition of the respective limits for the chosen subjects. |
| Module content | Depending on the choice of individual course composed subject areas. |
| Courses | Selection of courses in the range of 6 to 15 ECTS from<br>non-selected elective modules<br>specially marked courses ("WFM: ...") |
| Type of exam | Individual exams per course |

| Module description | **Individual Elective Module B** |
|---|---|
| Module code | IMB |
| Total workload | 6 to 15 ECTS |
| Learning outcomes | Subject competence: knowledge and deepening of central concepts and procedures combined with special extensions of the chosen subjects master and understand.<br>Methodological and practical competence: extended ability to independently and objectively apply in-depth methods to solve relevant problems in the chosen subjects.<br>Critical judgment competence: Assessment of concepts and procedures with regard to their applicability to specific problems, including the associated effects, and recognition of the respective limits for the chosen subjects. |
| Module content | Depending on the choice of individual course composed subject areas. |
| Courses | Selection of courses in the range of 6 to 15 ECTS from<br>non-selected elective modules<br>specially marked courses ("WFM: ...") |
| Type of exam | Individual exams per course |

## Annex III: Equivalency list

| **Masterstudium Informatik 2016** | | | | **Master's Degree Program in Computer Science 2023** | | | |
|---|---|---|---|---|---|---|---|
| **Lehrveranstaltung/Studienleistung** | **SSt** | **Typ** | **ECTS** | **Lehrveranstaltung/Studienleistung** | **SHrs** | **Type** | **ECTS** |
| **(1) Pflichtmodule** | | | | **Compulsory modules** | | | |
| Höhere Mathematik für Informatik | 3 | VO | 3 | Advanced Mathematics for Computer Science | 3 | VO | 3 |
| Höhere Mathematik für Informatik | 2 | PS | 4 | Advanced Mathematics for Computer Science | 2 | PS | 4 |
| Theoretische Informatik | 3 | VO | 3 | Theoretical Computer Science | 3 | VO | 3 |
| Theoretische Informatik | 2 | PS | 4 | Theoretical Computer Science | 2 | PS | 4 |
| Advanced Algorithms and Data Structures | 3 | VO | 3 | Advanced Algorithms and Data Structures | 3 | VO | 3 |
| Advanced Algorithms and Data Structures | 2 | PS | 4 | Advanced Algorithms and Data Structures | 2 | PS | 4 |
| | | | | | | | |
| Datenbanken Vertiefung | 2 | VO | 2 | Advanced Databases | 2 | VO | 2 |
| Datenbanken Vertiefung | 1 | PS | 2 | Advanced Databases | 1 | PS | 2 |
| Software Techniken | 2 | VO | 2 | Software Techniques | 2 | VO | 2 |
| Software Techniken | 1 | PS | 2 | Software Techniques | 1 | PS | 2 |
| Seminar aus Informatik | 2 | SE | 5 | Seminar in Computer Science | 2 | SE | 5 |
| | | | | | | | |
| Enterprise Computing | 2 | UV | 4 | Enterprise Computing | 2 | UV | 4 |
| Verteilte Systeme | 2 | VO | 2 | Distributed Systems | 2 | VO | 2 |
| Verteilte Systeme | 1 | PS | 2 | Distributed Systems | 1 | PS | 2 |
| IT-Sicherheit | 2 | VO | 2 | IT-Security | 2 | VO | 2 |
| IT-Sicherheit | 1 | PS | 2 | IT-Security | 1 | PS | 2 |
| Software Systems | 3 | UV | 4 | Advanced Systems Engineering | 3 | UV | 4 |
| | | | | | | | |
| **(2) Wahlmodule lt. § 6** | | | | **Elective modules according to § 6** | | | |
| **Anwendungsmodule** | | | | Courses for matching modules | | | |
| **Wahlfachmodule** | | | | | | | |

## Annex IV: Application procedure

The application procedure consists of two phases:
**Phase 1: Online application**

Generally, all submitted foreign documents, including all certificates and confirmations, must be verified by the country of origin and acknowledged by the Austrian representation authorities in that country (see the admissions department website).

According to the admissions department website, documents issued for example by EU authorities are not considered foreign documents.

Students have to provide the following documents for their online application:

- Application form
- Bachelor's diploma, diploma supplement (including course duration, description of the content and credits) and / or transcript of records including course titles, credit hours & grades
- Copy of passport
- Proof of language proficiency (e.g., school leaving certificate "Reifeprüfungszeugnis" within the EU)

Details including application deadlines can be found on the admissions department website.

**Phase 2: Preselection**

An admission team will decide whether applicants will be recommended for admission. This decision is communicated to the admission department of the University of Salzburg.

The final decision on admission is made by the University of Salzburg.

In case the documents provided do not lead to a clear decision in terms of the applicant's qualification, the admission team may conduct an additional (online) interview with the applicant.

Criteria for the interviews include:

- Key competences for the intended master's program
- Subject-related English skills
- Motivation, objectives, and expectations of the studies
- Previous academic achievements or practical experience

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