



TECHNISCHE
UNIVERSITÄT
WIEN

Bachelor

Master

Doctorate

Postgraduate

Curriculum
for the

Master's program
Visual Computing
UE 066 932

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§1 Foundation and Scope

The present curriculum defines and regulates the Master's program *Visual Computing* in ingenieur Sciences at the Technical University of Vienna. It is based on the Federal Act on the Organisation of Universities and their Studies – Universities Act 2002 UG (BGBl. I Nr. 120/2002 as amended) – and the Study Law Provisions of the Statutes of the Technical University of Vienna in their current version. The program has been structured and designed in alignment with the qualification profile, as detailed in § 2.

§2 Qualification Profile

Visual Computing deals with the acquisition, representation, processing, analysis, synthesis, and use of visual information, that is, images and image sequences in temporal and spatial context. The term Visual Computing has emerged from the methodological convergence of the fields of image processing, computer vision, computer graphics, visualization, augmented and virtual reality, machine learning, and human–computer interaction.

The Master's program *Visual Computing* provides advanced, scientifically and methodologically rigorous education aimed at long-lasting knowledge in these areas. It qualifies graduates both for further academic advancement, particularly within a relevant doctoral programme, and for employment in, for example, the following professional fields, while ensuring international competitiveness:

- Independent planning and implementation of innovative solutions in the field of Visual Computing
- Application of state-of-the-art analysis, modelling, and machine learning methods to creatively solve demanding, interdisciplinary development tasks
- Scientific and application-oriented research in both academic and industrial environments
- Leadership responsibilities in IT-related projects
- Consulting and training in companies, public administration, associations, organisations, etc.

Professional fields for graduates can be found in all areas of production and service industries where demanding and innovative problem-solving is required involving the generation or analysis of images by means of computers. These include, among others:

- the entertainment industry (computer games and film industry, advertising, television, internet applications, virtual reality systems, multimedia systems, consumer electronics, electronic publishing, as well as print media)
- virtual engineering (CAD/CAM systems)
- industrial production (assembly, sorting, quality control, monitoring)
- robotics and machine vision (robot navigation, driver assistance systems in the automotive industry)

- medicine (tomography, thermography, radiology and sonography with medical visualisation tools, as well as medical technology)
- security and criminology (biometrics and forensics, surveillance systems, identification imaging)
- information and telecommunication systems
- creation and automated evaluation of imagery in (micro-)biology, physics, weather forecasting, climate impact research, archaeology, geodesy, metallurgy, cartography
- art, culture, and cultural heritage (VR installations, virtual documentation and exhibitions)
- architecture and computational design (lighting simulation and planning, creation of BIM models, VR interaction and simulation)
- simulation and analysis of sustainable technologies

Based on professional requirements, the Master's program *Visual Computing* imparts qualifications in the following categories:

Technical competencies

- Image acquisition
- Image analysis (image processing, pattern recognition)
- Image synthesis (computer graphics, geometric modelling)
- Scientific visualization and information visualization
- Visual analytics and visual data science
- Human-computer interaction
- Augmented / Mixed / Virtual Reality
- Machine learning and artificial intelligence
- Relevant subjects such as signal processing, cognitive sciences, parallel and distributed computing
- Planning and evaluation of experiments
- Generative AI
- Fabrication
- Inverse and differentiable methods, e.g., inverse rendering
- Advanced methods from mathematics, computer science, and physics

Transversal competencies

- Scientific strategies for analysis, design, and implementation (incorporating the state of the art, critical evaluation, and reflection on solutions)
- Selection of appropriate formal-mathematical methods for modelling, abstraction, problem solving, and evaluation
- Interdisciplinary and system-oriented approaches with flexible thinking
- Goal-oriented working methodology
- Proficiency with technologies, software tools, and standards
- Comprehensive and precise written documentation of solutions
- Ability to deliver convincing technical presentations and communicate in an interdisciplinary environment

- Self-organisation, initiative, and personal responsibility
- Enhancement of individual creativity and innovation potential (curiosity)
- Problem formulation and problem-solving competence
- Communication and critical thinking skills
- Reflection on one's own abilities and limitations
- Competence for teamwork and responsibility in complex projects
- Decision-making responsibility and leadership skills in complex projects or tasks
- Impact assessment and ethical evaluation
- Strategic thinking and planning

§3 Time and effort

The workload for the Master's program *Visual Computing* is 120 ECTS points. This corresponds to an intended study duration of 4 semesters as a full-time program.

ECTS credits (ECTS) quantify the students' workload. One academic year comprises 60 ECTS credits, with one ECTS credit corresponding to 25 working hours (according to § 54 Abs. 2 UG).

§4 Admission to the Master's Program

Admission to a master's program requires the completion of a subject-relevant Bachelor's program or another subject-relevant program of at least the same educational level at a recognized domestic or foreign post-secondary educational institution.

A program of study is considered relevant if at least 120 ECTS have been completed in the subject areas of mathematics and computer science, including at least

1. 20 ECTS in mathematics and statistics, with the knowledge, skills, and competencies corresponding to the modules *Algebra und Diskrete Mathematik*, *Analysis*, and *Statistik und Wahrscheinlichkeitstheorie* of the bachelor's program *Informatics* at TU Wien;
2. 25 ECTS in algorithms, data structures, and programming, with the knowledge, skills, and competencies corresponding to the modules *Algorithmen und Datenstrukturen*, *Einführung in die Programmierung*, as well as for example *Datenbanksysteme*, *Programmierparadigmen*, *Software Engineering*, *Parallel Computing*, or *Betriebssysteme* of the bachelor's program *Informatics* at TU Wien;
3. 15 ECTS in the theoretical, technical, and practical foundations of computer science, with the knowledge, skills, and competencies corresponding to the module *Denkweisen der Informatik* as well as for example *Grundzüge digitaler Systeme*, *Theoretische Informatik*, *Einführung in Artificial Intelligence*, or *Einführung in Machine Learning* of the bachelor's program *Informatics* at TU Wien;

4. 18 ECTS in Visual Computing, with the knowledge, skills, and competencies corresponding to the modules *Einführung in Visual Computing*, *Grundlagen der Computergraphik*, and *Grundlagen der Computer Vision* of the bachelor's program *Informatics* at TU Wien.

In any case, without requiring supplementary examinations, graduates of the bachelor's program *Informatics* at TU Wien, provided that the specialization *Visual Computing* was chosen, as well as graduates of the bachelor's program *Media Informatics and Visual Computing* at TU Wien, are eligible.

To compensate for significant technical differences, supplementary examinations to the maximum extent of 30 ECTS may be prescribed, which must be completed by the end of the second semester of the Master's program at the latest. These may be used to a maximum extent of 4.5 ECTS in the module *Freie Wahlfächer und Transferable Skills* as free electives, but not as transferable skills. Furthermore, achievements obtained for acquiring the required knowledge, skills, and competences in the area of Visual Computing in accordance with Item 4 may be used within the module Extension up to an extent of 12 ECTS as part of the master's program.

The language of instruction is English. Applicants whose first language is not English must provide proof of the required language proficiency. The form of proof is specified in a regulation by the Rectorate.

Individual courses may be conducted in German, or individual lectures may be delivered in German, and/or supported by German-language materials. Therefore, proficiency in German at reference level B1 of the Common European Framework of Reference for Languages (CEFR) is recommended.

Some elective courses may be offered in German. For these courses, German language skills at reference level B1 of the Common European Framework of Reference for Languages are recommended.

§5 Structure of the Program

The content and qualifications of the program are delivered through *modules*. A module is a teaching and learning unit characterized by entry and exit qualifications, content, teaching and learning methods, regular workload, and assessment. Modules consist of one or more content related *courses*. Thematically linked modules are grouped into *examination subjects*, whose name, scope, and overall grade are listed on the graduation certificate.

Examination subjects and the associated modules

The Master's program *Visual Computing* consists of the following examination subjects and their assigned modules. Modules marked with Stern (*) are *elective modules*, while the others are *mandatory modules*. Mandatory modules must be completed in all cases.

In total, students must complete courses in the mandatory and elective modules, with the exception of the module *Freie Wahlfächer und Transferable Skills*, amounting to at least 81 ECTS credits.

In the module *Freie Wahlfächer und Transferable Skills*, students must take enough courses so that their combined credits, together with the master's thesis and the credits from the other mandatory and elective modules, total 120 ECTS or more.

If the total credits from the other mandatory and elective modules exceed 81 ECTS, the number of credits required in the module *Freie Wahlfächer und Transferable Skills* may be reduced accordingly. However, at least 4.5 ECTS credits in the area of transferable skills must still be completed within this module.

Computer Graphics

Computer Graphics (6,0 ECTS)

- *Algorithmic Geometry (6,0 ECTS)
- *Computer Animation and Simulation (6,0 ECTS)
- *Geometry Processing (6,0 ECTS)
- *Introduction to Geometry (6,0 ECTS)
- *Rendering (6,0 ECTS)
- *Advanced Topics In Computer Graphics (min. 3,0 ECTS)

Computer Vision

Computer Vision (6,0 ECTS)

- *3D Vision (6,0 ECTS)
- *Computer Vision Systems Programming (6,0 ECTS)
- *Medical Image Processing and Machine Learning (6,0 ECTS)
- *Scene Understanding and Surveillance (6,0 ECTS)
- *Video Analysis (6,0 ECTS)
- *Advanced Topics In Computer Vision (min. 3,0 ECTS)

Visualization

Visualization (6,0 ECTS)

- *Information Visualization (6,0 ECTS)
- *Medical Visualization and Visual Analytics (6,0 ECTS)
- *Graph Drawing Algorithms (6,0 ECTS)
- *Advanced Topics In Visualization (min. 3,0 ECTS)

Virtual and Augmented Reality

Virtual and Augmented Reality (6,0 ECTS)

- *Mixed Reality Lab (6,0 ECTS)

- *Multimodal Interfaces (6,0 ECTS)
- *Advanced Topics in Virtual Reality (min. 3,0 ECTS)

Machine Learning for Visual Computing

Machine Learning for Visual Computing (6,0 ECTS)

- *Deep Learning for Visual Computing (6,0 ECTS)
- *Media and Brain (6,0 ECTS)
- *Similarity Modeling (6,0 ECTS)
- *Statistical Pattern Recognition (6,0 ECTS)

Methods in Visual Computing

Seminar in Visual Computing (3,0 ECTS)

Project in Visual Computing (6,0–12,0 ECTS)

- *Numerical Computation (6,0 ECTS)

Extension

- *Extension (up to 12,0 ECTS)

Free Electives and Transferable Skills

Freie Wahlfächer und Transferable Skills (9,0 ECTS)

Diploma Thesis

See Section § 9.

Brief description of the modules

This section briefly characterizes the modules of the Master's program *Visual Computing*. A detailed description is available in Appendix A.

3D Vision (6,0 ECTS) This module offers a thorough introduction to the field of 3D Computer Vision, covering critical challenges, foundational theories, key mathematical principles, and practical algorithms. Students will engage in hands-on exercises to reinforce their understanding and apply the concepts learned in real-world scenarios. The module introduces fundamental concepts of three-dimensional imaging and its wide-ranging applications. It delves into image acquisition techniques and highlights the role of camera calibration in achieving accurate 3D data capture. Core topics include active range finders and range scanners, which facilitate depth and shape measurement. The module further explores methods for deriving object shapes from monocular, stereo, and multiple images and advanced approaches such as registration and space carving for 3D reconstruction. Finally, the module discusses cutting-edge applications, including

medical 3D imaging and 3D printing, emphasizing the practical relevance of 3D vision across various fields. Exercise parts focus on transforming physical objects into detailed 3D digital models, providing hands-on experience to deepen the content. Participants will follow the workflow from image capture to creating a final 3D object, learning to manage data collection and processing. It highlights key concepts such as point cloud generation and mesh optimization while addressing real-world challenges.

Advanced Topics In Computer Graphics (min. 3,0 ECTS) This module deepens knowledge in selected areas of computer graphics. Exemplary topics include color theory, fractals, visual data science and design of rendering engines.

Advanced Topics In Computer Vision (min. 3,0 ECTS) This module introduces advanced topics in Computer Vision, focusing on three areas: Computer Vision in Industry, Cultural Heritage Preservation, and Document Analysis. CV in Industry covers theoretical foundations, core concepts, and relevant background information for industrial applications. A guided excursion during the latter half of the semester provides hands-on experiences through field trips, on-site observations, and interactive sessions. CV for Cultural Heritage Preservation explores preservation and management techniques using state-of-the-art technologies. Students gain insights through real-world examples from excavations, museums, and sites like churches and castles. Document Analysis focuses on structuring document content for computer systems, including processes like transferring handwritten data into electronic templates. Advanced topics in this area include Multispectral Image Acquisition, Writer Identification, Layout Analysis, Large Language Models (LLMs), and Pre-Processing.

Advanced Topics in Virtual Reality (min. 3,0 ECTS) This module introduces Advanced Topics in Virtual and Augmented Reality (VR/AR). Students strengthen their VR and AR development skills by implementing a small project with advanced VR/AR. It includes studying and developing a particular topic, either alone or in small groups.

Advanced Topics In Visualization (min. 3,0 ECTS) This module deepens knowledge in selected areas of visualization, like visual data science.

Algorithmic Geometry (6,0 ECTS) Algorithmic geometry deals with efficient computations on basic geometric objects such as points, lines, polygons, and their higher-level analogs. Geometric algorithms play an important role in a variety of applications, e.g., visual computing, geographic information systems, machine learning, robotics, etc. This module studies the design and analysis of geometric algorithms and efficient data structures. We present fundamental techniques and concepts in algorithmic geometry as well as more advanced results and discuss selected geometric problems arising in applications.

Computer Animation and Simulation (6,0 ECTS) The module covers fundamental theories and techniques in computer animation and simulation for creating realistic character motion, simulating natural phenomena, or developing interactive virtual environments.

Computer Graphics (6,0 ECTS) The module covers the methodology for solving problems in computer graphics, with a focus on interactive and real-time rendering.

Computer Vision (6,0 ECTS) This module covers computer vision, including foundational theories, essential mathematical concepts, the use of machine learning, and practical algorithms. Key topics include the Structure of Images, dealing with image formation, texture, scenes, and context; Local and Multiscale Representations and Image Analysis, dealing with techniques for processing and comprehending image content; Scene Analysis and machine learning methods for computer vision, including deep learning; and finally topics such as Depth Perception, Reconstruction Techniques, and Multiview Geometry, with a focus on 3D understanding and its applications.

Computer Vision Systems Programming (6,0 ECTS) This module covers insights concerning all individual steps of a computer vision project: planning and effort estimation, data acquisition and data quality assessment, implementation, and evaluation of the results; but also questions of interdisciplinary collaboration, as well as legal and ethical considerations. Ongoing research projects and the path from research to market are discussed. Business planning and starting a business in computer vision are discussed.

Deep Learning for Visual Computing (6,0 ECTS) This module provides an introduction to the main concepts of Deep Learning through computer vision and computer graphics applications. This includes basic concepts such as feed-forward neural networks and more advanced concepts such as diffusion-based generative models or self-supervised techniques to train models without annotations. The module also explores how the techniques used for image data can be applied to other data types like 3D volumes, point clouds, or graphs.

Extension (up to 12,0 ECTS) This module allows students to extend their profile either by choosing courses from other Master curricula that fit the qualification profile of *Visual Computing*.

Freie Wahlfächer und Transferable Skills (9,0 ECTS) Die Lehrveranstaltungen dieses Moduls dienen der Vertiefung des Faches sowie der Aneignung außerfachlicher Kenntnisse, Fähigkeiten und Kompetenzen.

Geometry Processing (6,0 ECTS) This module covers the mathematical foundations of geometry processing and modeling, including curves and surfaces, as well as methods to create, process and simulate 3D geometric models.

Graph Drawing Algorithms (6,0 ECTS) Graph drawing is concerned with the geometric representation of graphs in the plane and constitutes the algorithmic core of network visualization. The research area of graph drawing combines aspects of algorithmics, graph theory, computational geometry, and visualization. In this module we define common aesthetic quality criteria and layout styles in graph drawing. Subsequently, we study the corresponding optimization problems from a formal, algorithmic perspective. We cover some of the most fundamental graph drawing algorithms, ranging from general-purpose algorithms to specific algorithms for certain graph classes (e.g., trees and planar graphs). The algorithms use known algorithm design principles such as divide-and-conquer, incremental constructions, and network flow models. The module covers both practical and theoretical aspects of graph drawing.

Information Visualization (6,0 ECTS) This module covers theoretical concepts and practical applications of information visualization, which is defined as the use of computer-supported, interactive, visual representations of abstract data to amplify cognition.

Introduction to Geometry (6,0 ECTS) This module covers the mathematical foundations of visual computing; including affine, Euclidean, projective and differential geometry, as well as basic topology and vector analysis.

Machine Learning for Visual Computing (6,0 ECTS) This module introduces fundamental machine learning concepts through computer vision examples. It focuses on a selected set of core topics, which form the basis for understanding essential machine learning principles. By implementing models independently in the lab, students gain deeper insights into these methods.

Media and Brain (6,0 ECTS) This module enables students to understand the essential connections in the human brain, to assess the conditions under which consciousness arises and to evaluate the process of how communicating centers in the brain generate perception.

Medical Image Processing and Machine Learning (6,0 ECTS) This module offers a comprehensive introduction to medical image processing and machine learning, focusing on their applications in healthcare, diagnostics, and clinical research. It will cover topics such as image segmentation, feature extraction, and the use of machine learning algorithms for disease detection and prediction to support clinical decision-making and research advancements.

Medical Visualization and Visual Analytics (6,0 ECTS) This module offers a comprehensive introduction to medical visualization and visual analytics, focusing on their applications in healthcare, bioinformatics, neuroinformatics, and public health. It combines foundational theories, computational techniques, and practical applications, covering topics such as brain imaging, genomic data visualization, and AI-driven visual analytics to support clinical and research decision-making.

Mixed Reality Lab (6,0 ECTS) This module teaches advanced techniques for 3D visualization and interaction in mixed reality using specialized hardware and software tools. These techniques include stereoscopic rendering on LED walls, rendering on LED walls for virtual production, usage of autostereoscopic displays, spatial sound rendering using a many-channel audio system, spatial 3D target tracking, and real-time DMX light control. The implementation will be done using a popular game engine. Students will get access to state-of-the-art mixed reality hardware, and they will learn how to create their own projects using the presented technologies.

Multimodal Interfaces (6,0 ECTS) This module introduces MultiModal Interfaces (MMI). Students gain basic knowledge regarding how multimedia and multisensory 2D or 3D input can be integrated to interact with virtual environments. Psychological and basic neuroscience aspects are presented to help students understand the importance of human factors in the design of MMI. The area includes an overview of current research

areas and applications in order to provide students with the technical and scientific skills to design and develop sensor-based interfaces that will improve user experience. In this module, we cover diverse MMIs such as haptics (tangible user interfaces and objects), taste and smell interfaces, bio-signal feedback, ubiquitous computing, embedded sensors and screens, large multi-touch systems, and interaction using gestures.

Numerical Computation (6,0 ECTS) Studierende werden mit den grundlegenden Konzepten algorithmisch-numerischer Lösungsmethoden vertraut gemacht. Inhaltlich gehören dazu grundlegende Fehlerbegriffe (Datenfehler, Verfahrens- oder Diskretisierungsfehler, Rundungsfehler), Kondition mathematischer Probleme, numerische Lösung linearer und nichtlinearer Gleichungssysteme, polynomiale Interpolation und Approximation, numerische Integration, numerische Lösungen von Differentialgleichungen, Design und Verwendung numerischer Algorithmen bzw. numerischer Software.

Project in Visual Computing (6,0–12,0 ECTS) In this module, practical problems from the field of Visual Computing are solved. This gives insights into scientific practice and current research in Visual Computing. To tackle larger problems, two practical projects can be combined.

Rendering (6,0 ECTS) This module covers photorealistic rendering techniques, including online and offline methods.

Scene Understanding and Surveillance (6,0 ECTS) This module covers the analysis of multimodal image sequences like RGB, thermal, and 3D to understand sensed scenarios. Additionally, lensless imaging is presented as a data source. The module includes topics of sensor technology, motion detection, object tracking, scene reconstruction, and performance evaluation. Issues of computer-aided event detection in videos are discussed. Additionally, ethics and GDPR issues for surveillance are addressed.

Seminar in Visual Computing (3,0 ECTS) In the seminar, students dive deeper into the literature of one chosen topic in Visual Computing (i.e., Computer Graphics, Computer Vision, Image Processing, Visualization, or Augmented and Virtual Reality) and present their findings in written and oral form.

Similarity Modeling (6,0 ECTS) In this module, students learn to teach computers to see and hear using classical methods of signal processing and machine learning. They analyze media streams and develop algorithms for summarizing media data and classifying these summaries. In addition, they learn which advanced methods of artificial intelligence and information retrieval are particularly suitable for solving complex problems of media comprehension and how they can be used in practice. In the exercise part, students apply their theoretical knowledge to solve selected problems of audio, image and video comprehension through modeling, programming and iterative refinement. Finally, they reflect on what they have learned in groups in a media comprehension seminar.

Statistical Pattern Recognition (6,0 ECTS) This module repeats and expands relevant concepts from probability theory and inductive logic, including classification, regression and parameter estimation, both from a frequentist and Bayesian perspective.

Video Analysis (6,0 ECTS) This module addresses principal techniques of video analysis and selected topics of visual human motion analysis for applications such as autonomous driving and human-robot interaction.

Virtual and Augmented Reality (6,0 ECTS) This module introduces virtual and augmented reality (VR/AR). Students gain basic knowledge via VR/AR hardware and software, 3D input, output methods, and user-specific aspects. In addition, psychological and basic neuroscience aspects are presented to help students understand the importance of human factors in the design of VR/AR systems. The module includes an overview of current research areas and applications in order to provide students with the technical and scientific skills to design and develop VR/AR applications. The module also aims to provide a deeper understanding of design methods, production methods, reception, and use of concrete forms of VR/AR systems.

Visualization (6,0 ECTS) After successful completion of the module, the students understand advanced theoretical concepts of visualization. Furthermore, students are able to research, implement, and extend state-of-the-art visualization algorithms to interactively analyze large and complex data as well as reflect on issues concerning ethics, gender, and diversity.

§6 Courses

The subject areas of the modules are conveyed through courses. The courses of each module are specified in the respective module description in Appendix A. Courses are assessed through examinations as defined in the UG. The types of course assessments are defined in the examination regulations (Paragraph §7).

Requirements for courses and examinations from the Federal Act on the Organisation of Universities and their Studies (Universities Act 2002 – UG)

Before the start of each semester, an electronic directory of courses must be published (title, name of the lecturer, type, form including location and dates of the course). This directory is to be continuously updated. In addition to the published directory, the lecturers of a course must inform the students - before the start of each semester - in an appropriate manner about the objectives, form, content, dates, and methods of their courses as well as the content, form, methods, dates, assessment criteria, and assessment standards of the examinations. For examinations conducted as a single examination event, at least three examination dates per semester must be scheduled (according to the statute at the beginning, middle, and end), and students must be informed about the content, form, methods, dates, assessment criteria, and assessment standards of the examinations before the start of each semester. For examinations conducted using electronic communication tools, proper conduct of the examination must be ensured, in

addition to the general examination regulations, the following minimum requirements must be met:

- Prior to the beginning of the semester, students must be informed about the technical standards that their equipment must meet to participate in these examinations.
- To ensure the independent completion of the examination by the student, technical or organizational measures must be implemented.
- If technical problems occur not caused by the student, the examination must be aborted and not counted towards the permissible number of examination attempts.

Guidelines for Courses from the Statutes of TU Wien

In the following context, SSB stands for *Satzung der TU Wien, Studienrechtliche Bestimmungen* (Statutes of TU Wien, Study Law Provisions)

- The scope of the course must be specified in ECTS credits and semester hours. cf. § 9 (2) SSB - Modules and Courses
- Courses can be held as “block courses” with the approval of the governing body responsible for study matters. cf. § 9 (3) SSB - Modules and Courses
- Courses and exams can be conducted in a foreign language with the approval of the governing body responsible for study matters. cf. § 11 (1) SSB - Foreign Languages
- Course exams serve as proof of the learning outcomes conveyed by an individual course. cf. § 12 (1) SSB - Course Exam
- Course exams must be conducted by the course instructor. If necessary, the governing body responsible for study matters can appoint another suitable examiner. cf. § 12 (2) SSB - Course Exam
- For exams ending in a single examination act, three exam dates must be set for the beginning, middle, and end of each semester. These dates must be announced before the start of the semester. cf. § 15 (1) SSB - Exam Dates
- Exams can be conducted at the beginning and end of non-teaching periods. cf. § 15 (1) SSB - Exam Dates
- Exam dates must be announced in an appropriate manner. cf. § 15 (1) SSB - Exam Dates

Description of Course Types

VO (Lecture): Courses where the content and methods of a subject are presented, focusing on specific issues, concepts, and solutions. Exams are conducted in a single act. The exam type (written, oral, or both) must be specified in the module description. No attendance requirement, but achievement of learning outcomes must still be ensured.

EX (Excursion): Courses held outside TU Wien. They aim to deepen the learning content in the respective local context.

LU (Laboratory Exercise): Courses where students solve experimental tasks either individually or in groups under the guidance of a supervisor, in order to learn how to handle equipment and materials as well as the experimental methodology of the subject. The experimental facilities and workplaces are provided.

PR (Project): Courses where students deepen and complement their understanding of specific areas by solving concrete experimental, numerical, theoretical, or artistic tasks. Projects are aligned with the qualification profile of the programme and supplement professional or scientific training.

SE (Seminar): Courses where students work on a given topic or project using scientific methods, involving reflection on problem-solving and scientific discourse.

UE (Exercise): Courses where students work on specific tasks (e.g., computational, constructive, artistic, or experimental) under professional guidance to develop their skills and abilities in applying knowledge to concrete tasks.

VU (Lecture with Integrated Exercise): Courses combining lecture and exercise, where the exercise and lecture parts must each constitute at least a quarter of the total course content. The exercise part is always continuously assessed, while the lecture part can be assessed through a single exam act or continuously. It is not permissible to assess the entirety of the course in a single examination act.

Course and Exam Descriptions in the Information System for Studies and Teaching

- Course type (VO, EX, LU, PR, SE, UE, VU)
- Form (Presence, Online, Hybrid, Blended)
- Dates (Including necessary attendance for successful completion)
- Contents (Description of contents, prerequisites)
- Literature references
- Learning Outcomes (Comprehensive description of learning outcomes)
- Methods (Description of methods in alignment with learning outcomes and performance assessment)
- Performance Assessment (In alignment with learning outcomes and methods)
 - Indication of partial achievements, indicating which can be retaken. This point does not apply to VO courses.
- Exams:
 - Contents (Description of contents, literature)
 - Form (Presence, Online)
 - Exam Type and Mode:
 - * Type VO: Written, oral, or both;
 - * Other types: Indication of partial achievements including type and mode related to the course's pursued learning outcomes.

- Dates (Indication of dates)
- Assessment Criteria and Standards

§7 Examination Regulations

For the completion of the Master's program, the following are required:

1. the successful completion of the modules prescribed in the curriculum, where a module is considered successfully completed if the courses attributable to it have been successfully completed according to the module description,
2. the completion of a successfully evaluated master's thesis, as well as the successful completion of the course *Seminar für Diplomand_innen*, and
3. the successful completion of the committee-based final exam, which is conducted orally before an examination committee pursuant to § 13 and §19 of the Study Law Provisions of the Statutes of TU Wien. It serves to present and defend the master's thesis and to demonstrate the candidate's command of the relevant scientific field. Particular emphasis should be placed on understanding and overview knowledge. The prerequisites for registering for the committee-based final exam pursuant to § 17 Abs.1 of the Study Law Provisions of the Statutes of TU Wien are fulfilled if items 1 und 2 have been completed.

The final certificate includes:

- (a) the exam subjects with their respective scope in ECTS credits and grades,
- (b) the topic and grade of the master's thesis,
- (c) the grade of the committee-based final exam,
- (d) the overall assessment, and
- (e) upon request, the overall grade of the completed program according to § 72a UG..

The grade for the subject "Master's Thesis" is derived from the grade of the thesis. The grade for each other exam subject is calculated as the weighted average of the grades from the courses assigned to the subject through the corresponding modules. The weighting is based on the ECTS credits of each cours. If the resulting average includes a decimal of 0.5 or less, it is rounded down; if it is greater than 0.5, it is rounded up. If no exam subjects is graded worse than "good" and at least half are graded "very good," the overall assessment is "passed with distinction"; otherwise, the assessment is "passed."

Courses of type VO are assessed based on a final oral and/or written exam. All other courses have continuous assessment, i.e., ongoing performance checks and optionally a final partial exam.

The successful completion of exams and scientific as well as artistic works is graded as “very good” (1), “good” (2), “satisfactory” (3), or “sufficient” (4), whereas failure is graded as “unsatisfactory” (5). For courses where a differentiated grade is not applicable, the assessment is recorded as either “successfully participated” (E) or “unsuccessfully participated” (O).

§8 Feasibility of Studies and Mobility

Students in the Master’s program *Visual Computing* should be able to complete the programme within the prescribed period with a reasonable amount of effort.

Students are advised to follow the recommended semester plan provided in the appendix D.

The assessment and attendance modalities for courses of types UE, LU, PR, VU, SE, and EX are to be established within the framework of teaching agreements with the governing body responsible for study matters and published in the information system for studies and teaching in an appropriate form. With regard to the repeatability of partial assessments, reference is made to the academic regulations in the university statutes.

In accordance with UG § 58 para. 8, every course with limited number of participants, where a student’s intended participation cannot be accommodated and this has the potential to delay the student’s progress, must be listed in the curriculum along with the number of available places and the allocation procedure. The courses affected, as well as the number of places and the allocation process, must be determined by the Study Committee and clearly and understandably presented to students in the module descriptions.

Course instructors are authorized to grant exceptions to the participation restrictions for their courses.

The recognition of academic achievements completed abroad is to be carried out by the governing body responsible for study matters (Dean of Studies).

The options listed in Statutes - Study Law Provisions § 27 Abs. 1 bis 3 are available to facilitate mobility. In individual cases, these provisions can also be used to improve the feasibility of studies.

ECTS credits earned as part of a mobility program can be used to fulfill the required transferable skills in the module “Free Electives and Transferable Skills” to the appropriate extent. In particular, such exams are assigned to the category “Diversity Management” and thus to the pool of technology assessment, technology genesis, scientific ethics, gender mainstreaming and diversity management.

When assessing the essential differences in the acquired competencies of courses or modules completed during mobility, it is recommended to focus on technical competencies.

If a course without an explicitly regulated admission procedure faces an unexpected surge in demand, the course instructor may impose participation restrictions in consultation with the academic authority. Students admitted to the Master’s programme *Visual*

Computing who would face a delay in their studies due to non-participation must in any case be accepted. The allocation of any remaining places shall be governed by the following criteria (in descending order of priority):

- Students who meet the formal and substantive prerequisites shall be given priority. The substantive prerequisites may be verified, for example, on the basis of examinations already completed or by means of an entrance test.
- Among these students, using the course as a mandatory course has priority over using it as an elective, and using it as an elective has priority over using it as a free elective.
- Within each of these three groups, students who were rejected in an earlier semester despite meeting all prerequisites shall be given preference.

Students must be informed of this as soon as possible.

§9 Master's Thesis

The thesis is a artistic-scientific work that serves to demonstrate the ability to handle a topic autonomously processed in a manner that is reasonable in terms of content and methodology.

The topic of the thesis is freely chosen by the student and must be in line with the qualification profile. The examination subject of the master's thesis encompasses 30 ECTS credits and includes, in any case, the scientific work (thesis) evaluated at 27 ECTS credits, a seminar for thesis candidates worth 1,5 ECTS-credits and the committee final examination worth 1,5 ECTS-credits.

§10 Academic Degree

Graduates of the Master's program *Visual Computing* are awarded the academic degree "Diplom-Ingenieur"/"Diplom-Ingenieurin" – abbreviated as "Dipl.-Ing." or "DI" (abbreviated as "Master of Science").

§11 Quality Management

The quality management of the Master's program *Visual Computing* ensures that the program is designed consistently in accordance with the study-related quality objectives of TU Wien and is executed efficiently and effectively as well as regularly reviewed. The program's quality management follows the Plan-Do-Check-Act model based on standardized processes and is designed to be target-group-oriented. The target groups of quality management are, internally, the students and the teaching staff, and externally, society, economy, and administration, including the labor market for graduates.

Taking into account the defined target groups, six objectives are established for the quality of academic programs at TU Wien: (1) Ensuring the relevance of the qualification profile for society and the labor market. (2) Appropriately designed learning outcomes in the modules of the curriculum, supporting the qualification profile. (3) Appropriately selected learning activities and methods to achieve learning outcomes. (4) Appropriate assessment methods to verify the achievement of learning outcomes. (5) Ensuring conditions for the feasibility of study plans. (6) Ensuring that the teaching staff possesses the subject-specific and time resources to ensure high-quality teaching.

To ensure the quality of the academic programs, progress in planning, development, and assurance of all six quality objectives is collected separately and published. Quality assurance verifies the achievement of these objectives. For the assessment of the first and second quality objectives, the study committee (Studienkommission) conducts at least one review of the qualification profile and module descriptions per term of office. Ongoing evaluations by students, as well as individual feedback on the academic operation to the governing body responsible for study matters, provide a comprehensive picture of the curriculum implementation. Ongoing review also helps identify critical courses, for which appropriate adjustments are derived and implemented in coordination between the governing body responsible for study matters, study committee, and course instructors. The sixth quality objective is covered by quality-assurance instruments in the personnel area. In addition to internal quality assurance, external evaluation of the studies is conducted every seven years.

Each module has a module coordinator responsible for the content coherence and quality of the courses assigned to the module. This responsibility is ensured through cyclical checks, content alignment with preceding and subsequent modules, and comparison with similar courses or modules at other universities, both domestic and international.

Course Capacities

To ensure the quality of course delivery, the following group sizes serve as a guideline for the different types of courses (see page 14):

Course Type	Group Size	
	per Lecturer	per Tutor
VO	100	
UE with Tutors	30	15
UE	15	
LU with Tutors	20	8
LU	8	
EX, PR, SE	10	

For courses of type VU, the group sizes for VO and UE are applied to the lecture and exercise parts, respectively. The assignment of instructors is made according to the actual course delivery.

Gender, Ethics and Diversity

Context: To create teaching and learning environments in which all students — regardless of gender, origin, abilities, or social background — are equally valued, supported, and challenged, inclusive teaching based on diversity-sensitive didactics is required. This cannot be handled in separate, standalone courses but must be implemented at all levels of the program — as an “Embedded Gender, Ethics and Diversity” approach.

This includes the integration of ethical and societal topics into the curriculum, as well as engagement with these topics in every course. In this way, conditions can be created that enable a discrimination-free learning environment. This also includes measures against discrimination and harassment, for example through explicit codes of conduct.

Curriculum content: Inclusivity and diversity are promoted by incorporating different perspectives in all courses, drawing on a wide spectrum of authors and role models. Ethical reflection of core areas is embedded in all courses by addressing and considering ethical aspects and social impacts in lectures and exercises, for example through discussions of these topics. Additionally, reference is made to the offerings of the TU Wien Department for Gender Competence, which issues the certificate *Gender and Diversity Competence* for completing an additional course catalog.

Teaching methods: Teaching methods promote gender inclusivity and diversity and create a learning environment in which all students feel equally welcome. This includes, among other things, the use of inclusive, bias-free language to avoid reinforcing stereotypes; teaching materials with examples, case studies, or visual materials that reflect our diverse society; conducting courses in a format suitable for people with different abilities to ensure equal participation; and the inclusion of guest speakers from diverse backgrounds.

§ 12 Entry into Force

This curriculum enters into force on 1 October 2026.

§ 13 Transitional Provisions

All valid transitional provisions are listed in Appendix B of the curriculum.

A Module Descriptions

The lectures associated with the modules are listed in the following format:

9,9/9,9 XX Titel of the course

Where the first number represents the scope of the course in ECTS credits, and the second number represents its extent in semester hours. ECTS credits measure the student's workload, with one academic year comprising 60 ECTS credits, and one ECTS credit equivalent to 25 hours of 60 minutes each. A semester hour corresponds to as many teaching units as the semester has weeks of instruction. Each teaching unit lasts 45 minutes. The type of lecture (XX) is explained in detail in the paragraph §6 on page 14.

3D Vision

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- collect, develop, evaluate, and interpret information related to 3D computer vision
- identify requirements and boundary conditions in various areas of 3D computer vision
- apply their knowledge to tackle complex tasks in the field
- devise and present solutions and arguments for these challenges
- name, explain, and compare the key theories, principles, concepts, and algorithms in 3D computer vision. Their knowledge and understanding will be aligned with the current state of the art in computer vision.
- handle subject-specific hardware and software and to successfully convert real objects into 3D models.
- use Geomagic Wrap as a professional 3D editing program.
- create a 3D model from photographs using a Structure from Motion program.

Non-technical competencies: In this module, students learn to

- tap their creative potential
- communicate effectively in a team
- present a software application to a large group

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. Training datasets in 3D systems often overrepresent Western, able-bodied, young, and male individuals, which may compromise accuracy for diverse groups, including those with varied body types, disabilities, or non-Western features. Students will cultivate the skills necessary to address these challenges by advocating for diverse gender identities and promoting customizable, non-stereotypical representations. While 3D vision technologies may marginalize certain groups, they also present advantages, such as assistive tools that

improve accessibility for individuals with disabilities. However, technologies like 3D facial recognition raise significant privacy and surveillance issues, particularly for vulnerable populations. Students will learn to acknowledge their responsibility in addressing the impacts of EGD and to uphold accountability when employing 3D vision technologies.

Content:

- fundamental concepts of **3D acquisition**, covering all key techniques used to capture three-dimensional objects digitally
- image acquisition techniques, particularly camera calibration
- depth and shape measurement using active range finders and range scanners
- deriving object shapes from monocular, stereo, and multiple images
- registration and space carving for 3D reconstruction
- medical 3D imaging and 3D printing
- using a software package for the reconstruction process, providing a professional toolset for processing and refining 3D models.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU 3D Vision

Advanced Topics In Computer Graphics

Workload for the module: min. 3,0 ECTS

Learning Outcomes: The module provides in-depth knowledge and understanding of important sub-areas of computer graphics.

Technical competencies:

- Students can name, explain and contrast the most important theories, principles, concepts and algorithms in specific topics of computer graphics. Their knowledge and understanding corresponds to the state of the art in computer graphics literature.

In particular, students can

- collect, develop, evaluate and interpret information relevant to computer graphics,
- determine requirements and constraints in different areas of computer graphics, and
- practically apply the acquired knowledge in complex computer graphics tasks, work out and further develop solutions to problems and argue for these solutions.

Non-technical competencies:

- Students are able to deepen their knowledge independently.

Content: This module deepens knowledge in selected areas of computer graphics. Exemplary topics include color theory, fractals, visual data science and design of rendering engines. The exact selection of topics varies from term to term.

Expected prerequisites: For most topics, knowledge of visualization will be helpful. These prerequisites are taught in the module *Computer Graphics*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The courses for this module are announced before each term.

Advanced Topics In Computer Vision

Workload for the module: min. 3,0 ECTS

Learning Outcomes: After successful completion of the module, students are able to:
Technical competencies:

- analyze specific problems in the field of Computer Vision
- design appropriate solutions
- implement a prototypical application.

Content:

1. Computer Vision in Industry

- Covers theoretical foundations, core concepts, and background information essential to understanding industrial applications of Computer Vision.
- Includes practical, hands-on experiences through a guided excursion planned during the latter half of the semester, featuring field trips, on-site observations, and interactive sessions to explore real-world applications.

2. Computer Vision for Cultural Heritage Preservation

- Focuses on Cultural Heritage (CH) preservation and management techniques.
- Provides insights into using state-of-the-art technologies in CH preservation through examples from excavations, museums, and sites such as churches, castles, and artifacts.
- Highlights the importance of advanced technologies in safeguarding cultural assets.

3. Document Analysis

- Aims to structure and unlock document content for computer systems, enabling further processing.
- Includes processes such as transferring customer data from handwritten forms into electronic templates.
- Covers advanced topics like Multispectral Image Acquisition, Writer Identification/Classification, Layout Analysis, Large Language Models (LLMs), and Pre-Processing.

Expected prerequisites: The module requires knowledge of different aspects of computer vision.

These prerequisites are taught in the module *Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The courses for this module are announced before each term.

Advanced Topics in Virtual Reality

Workload for the module: min. 3,0 ECTS

Learning Outcomes: After successful completion of the module, students are able to:
Technical competencies:

- Analyze an individual problem in the field of Virtual- and Augmented Reality, design an according solution and implement a prototypical application.
- Create a project in a small group, coordinating the implementation of a VR/AR system.
- Explain and demonstrate a developed VR/AR application to an audience.

Non-technical competencies:

- Understand usability, human factors, and accessibility to design VR/AR interfaces.
- Understand ethical, gender, and diversity considerations in the design of VR/AR systems and 3D interactions, such as gender effects in cybersickness, human factors in virtual environments, and improving accessibility in VR/AR interfaces.

Content:

- Advanced 3D interaction (e.g., mid-air interaction in immersive applications through hand tracking)
- Advanced multimodal user interfaces (e.g., integration of multiple sensor data und multisensory feedback synchronized)

- Perceptual illusions in immersive environments (e.g., rubber hand illusion, haptic retargeting, or redirected walking)
- Video-see-through head-mounted displays (HMDs) for more flexible creation of blended experiences.
- Use of state-of-the-art hardware (e.g., AR glasses, robots, locomotion platforms...)

Expected prerequisites: Knowledge in Object Oriented Programming (C#, C++), Virtual and Augmented Reality

These prerequisites are covered in the module *Virtual and Augmented Reality*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The courses for this module are announced before each term.

Advanced Topics In Visualization

Workload for the module: min. 3,0 ECTS

Learning Outcomes: The module provides in-depth knowledge and understanding of important sub-areas of visualization.

Technical competencies: After successful completion of the module, students are able to:

- name, explain and contrast the most important theories, principles, concepts and algorithms in specific topics of visualization. Their knowledge and understanding corresponds to the state of the art in visualization literature.
- collect, develop, evaluate and interpret information relevant to visualization,
- determine requirements and constraints in different areas of visualization, and
- practically apply the acquired knowledge in complex visualization tasks, work out and further develop solutions to problems and argue for these solutions.

Non-technical competencies:

- Students are able to deepen their knowledge independently.

Content: This module deepens knowledge in selected areas of visualization, like visual data science. The exact selection of topics varies from term to term.

Expected prerequisites: For most topics, knowledge of visualization will be helpful. These prerequisites are taught in the module *Visualization*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The courses for this module are announced before each term.

Algorithmic Geometry

Workload for the module: 6,0 ECTS

Learning Outcomes: This module introduces fundamental efficient algorithms and data structures for combinatorial geometric problems.

Technical competencies: Students will learn to

- explain fundamental concepts, structures, and problems in algorithmic geometry,
- design and analyze geometric algorithms and data structures,
- model geometric problems and adapt known algorithms and data structures to new problems, and
- investigate unknown geometric problems and develop new algorithmic solutions.

Non-technical competencies: Students will be able to

- perform formal reasoning, correctness proofs, and proofs of asymptotic time complexity of algorithms,
- structured analysis of computational problems,
- abstract problem modelling,
- judge trade-offs between time and space complexity, and
- being aware of possible ethical, gender, and diversity issues in the context of geometric data processing.

Content: The module content covers fundamental techniques and algorithms for geometric problems including

- basic geometric algorithms for computing convex hulls, polygon triangulations, and segment intersections,
- data structures for orthogonal range searching, windowing queries, and point location queries,
- Voronoi diagrams and Delaunay triangulations,
- point-line duality,
- distance approximation,
- geometric shortest paths and robot motion planning, and
- sweep-line algorithms and randomized incremental constructions.

Expected prerequisites: Extended knowledge of algorithms and data structures.

These prerequisites are taught in the following recommended modules:

- *Effiziente Algorithmen*
- *Algorithmics*

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Algorithmic Geometry

Computer Animation and Simulation

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successfully completing the module, students are able to

- identify, explain, and differentiate the most important theories, principles, concepts, and methodologies in the fields of Computer Animation and Simulation
- understand cutting-edge techniques and applications in animation algorithms, physics-based simulation, and real-time rendering
- implement animation techniques, including keyframe animation, procedural animation, and motion capture.
- describe physics-based simulation for realistic modeling of physical phenomena.
- apply real-time rendering techniques for interactive applications.
- list the challenges in simulating natural phenomena such as fluid dynamics, cloth behavior, and rigid body dynamics.
- design and implement simulation algorithms.
- evaluate animation and simulation methods for performance, realism, and computational efficiency.

Non-technical competencies:

- apply creativity to problem-solving.
- collaborate in groups.
- communicate competently.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes the representation of diverse identities in character design, inclusive storytelling, and the responsible use of simulated environments.

Content:

- Fundamental and advanced concepts in computer animation and simulation.
- 3D modeling, simulation, and rendering.
- Animation techniques and software tools.
- Physics-based simulations in animation.
- Real-world applications in gaming, film, and VR.
- Methods for implementing interactive animations and simulations.
- Evaluation of animation quality, realism, and computational performance.

Expected prerequisites:

- Basic understanding of 3D modeling and computer graphics concepts.
- Understanding of basic physics principles for simulating motion and forces.

- Experience with software tools like Blender, Maya, or Unity, would be beneficial but not required.

These prerequisites are partly taught in the module *Grundlagen der Computergraphik*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Computer Animation and Simulation

Computer Graphics

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students can

- describe advanced concepts of interactive computer graphics and real-time rendering as used in virtual reality applications or in computer games.
- explain the theoretical and mathematical background of computer graphics effects.
- implement a computer graphics system based on a low-level graphics API that shows advanced computer graphics effects.
- analyze and improve the performance of a computer graphics application.

Non-technical competencies: In this module, students learn to

- tap their creative potential
- communicate effectively in a team
- present a software application to a large group

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes aspects such as gender representations in 3D applications, energy efficiency in rendering algorithms, the ability of computer graphics algorithms to depict human features across diverse groups, and the design of graphics systems that accommodate different user needs, such as color blindness or visual impairments.

Content:

- Architecture of graphics hardware
- Performance optimization for graphics hardware
- Advanced lighting and shading (including physically based shading, normal mapping, ambient occlusion)
- Shading languages

- Graphics programming
- Shadows (hard and soft, rasterization and ray-tracing-based)
- Culling and visibility
- Levels of detail und terrain rendering
- Image-based rendering
- Perceptual aspects of rendering
- Screenspace effects
- Temporal coherence
- Real-time global illumination
- 3D Gaussian splatting

Expected prerequisites: Students should have programming skills in C++ as well as experience with a 3D API like OpenGL or Vulkan, and basic computer graphics knowledge.

These prerequisites are taught in the module *Grundlagen der Computergraphik*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Computer Graphics

Computer Vision

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- identify, explain, and contrast the most important theories, principles, concepts, and algorithms of computer vision
- understand the state-of-the-art literature in the field of computer vision
- apply appropriate formal-mathematical methods for modeling, abstraction, solution finding, and evaluation

Non-technical competencies: Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. In particular, this includes how algorithms can either reflect or exacerbate societal biases. For instance, facial recognition technology often demonstrates reduced accuracy for underrepresented groups, such as women and people of color, largely because of skewed datasets that predominantly feature white male faces. Students will cultivate skills to tackle these challenges by diversifying training data, thereby avoiding the

reinforcement of gender stereotypes. Recognition systems should also account for non-binary identities and cultural diversity, as models trained primarily on Western norms may misinterpret traditional attire.

Content:

- Basic interpretation of visual data from images and videos
- Structure of images (image formation, texture, scenes, and context)
- Local and multiscale representations and Image Analysis (processing and comprehending image content)
- Scene Analysis and machine learning methods for computer vision (including deep learning)
- 3D Understanding (depth perception, reconstruction techniques, multiview geometry)

Expected prerequisites: Basic knowledge in different topics of computer vision.

These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Computer Vision

Computer Vision Systems Programming

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- plan and estimate the effort required for a computer vision project, covering all stages from data acquisition and quality assessment to implementation and result evaluation.
- understand the importance of interdisciplinary collaboration
- navigate legal and ethical considerations
- and gain insights into the commercialization of computer vision technologies, including business planning and moving from research to market.

Non-technical competencies: Students gain insights into key concepts of entrepreneurship related to CV, including opportunity recognition, business model development, risk management, and innovation. In addition, students will:

- Understand ethical implications of deploying computer vision systems, especially regarding privacy, surveillance, and bias in AI.

- Be able to critically reflect on the societal impact of automated decision-making and data-driven technologies.
- Develop awareness of gender and diversity aspects in computer vision, including bias mitigation in datasets and algorithmic fairness.
- Gain perspective on responsible innovation through interdisciplinary discussions and real-world case studies.
- Develop goal-oriented/practical working methods, business motivated thinking and developing.

Content:

- CV-Projects and Applications
- Tools and libraries for CV Programming
- CV business cases and entrepreneurship
- Real-world applications, including excursion to CV-related company
- Exercises from real-world applications
- Presentations and discussions of project outcomes, techniques, and challenges

Expected prerequisites: Knowledge of computer vision and its fundamental methods. These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Computer Vision Systems Programming

Deep Learning for Visual Computing

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to:

- Understand basic deep learning concepts.
- Understand recent deep learning architectures commonly used to process and generate images and the mechanics to train them.
- Apply such concepts to other data types such as 3D volumes, point clouds, or graphs.
- Train a deep learning model on standard computer vision tasks such as classification or segmentation.

Non-technical competencies: Through deep learning, the student will be able to solve problems related to computer vision, computer graphics, visualization, and medical imaging. Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content.

Content:

- Brief recap of Machine Learning concepts: overview, parametric models, iterative optimization.
- Feedforward Neural Networks, backpropagation.
- Convolutional Neural Networks, Vision Transformers, and modern neural architectures.
- Self-supervised training.
- Generative models for image synthesis.
- Deep Learning for other types of data such as 3D volumes, point clouds, and graphs.
- Software libraries and practical aspects

Expected prerequisites: Knowledge in Machine Learning is recommended.

These prerequisites are taught in the module *Machine Learning for Visual Computing*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Deep Learning for Visual Computing

Extension

Workload for the module: up to 12,0 ECTS

Learning Outcomes: This module allows students to extend their profile by choosing courses from other Master curricula that fit the qualification profile of *Visual Computing* and from Bachelor curricula that contain knowledge required for successfully completing the modules in this curriculum as specified below.

Technical competencies: Depends on the chosen courses.

Non-technical competencies: Depends on the chosen courses.

Content: Depends on the chosen courses.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The courses in this module can be chosen freely from other Master curricula, provided they fit the qualification profile. Courses from other Informatics Master Curricula at TU Wien can always be chosen. Courses from Bachelor curricula can be chosen if they contain necessary prerequisites for modules of *Visual Computing* and correspond to modules explicitly listed in item 4 in § 4.

For the Master *Visual Computing*, the following courses are particularly recommended:

3,0/2,0 VO AKGEO Computer Aided Geometric Design

1,5/1,0 UE AKGEO Computer Aided Geometric Design

6,0/4,0 VU Algorithmics

6,0/4,0 VU Heuristic Optimization Techniques

6,0/4,0 VU GPU Computing And Architectures

6,0/4,0 VU Mobile Robotics

6,0/4,0 VU Generative AI

6,0/4,0 VU Responsible Digital Ethics

6,0/4,0 VU Advanced Software Engineering

6,0/4,0 VU Efficient Programs

Freie Wahlfächer und Transferable Skills

Workload for the module: 9,0 ECTS

Learning Outcomes: Die Lehrveranstaltungen dieses Moduls dienen der Vertiefung des Faches sowie der Aneignung außerfachlicher Kenntnisse, Fähigkeiten und Kompetenzen.

Content: Abhängig von den gewählten Lehrveranstaltungen.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: Die Lehrveranstaltungen dieses Moduls können frei aus dem Angebot an wissenschaftlichen und künstlerischen Lehrveranstaltungen, die der Vertiefung des Faches oder der Aneignung außerfachlicher Kenntnisse, Fähigkeiten und Kompetenzen dienen, aller anerkannten in- und ausländischen postsekundären Bildungseinrichtungen ausgewählt werden, mit der Einschränkung, dass zumindest 4,5 ECTS aus den Themenbereichen der Transferable Skills zu wählen sind. Für die Themenbereiche der Transferable Skills werden insbesondere Lehrveranstaltungen aus dem Wahlfachkatalog "Transferable Skills" der Fakultät für Informatik (Anhang F) und aus dem zentralen Wahlfachkatalog der TU Wien für "Transferable Skills" empfohlen.

Geometry Processing

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students can

- solve problems of planar and spatial geometry with standard methods
- list and compute the main geometric properties of curves and surfaces
- describe methods for the generation of 3D digital models and representations
- analyze surface properties
- run simulations on surfaces

Non-technical competencies: Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes aspects such as the representation of diverse human forms in 3D geometry, privacy considerations in 3D scanning and reconstruction, and questions of copyright and authorship in the use and generation of geometric models.

Content:

- Model representation (meshes, curves and surfaces, parametric surfaces)
- Differential geometry
- Reconstruction of 3D Models from Scans
- Fabrication
- Parametrization
- Simulations on Surfaces (Laplacian, Poisson equation, Finite Element Method, smoothing)
- Procedural Modeling (grammars, L-systems, shape grammars, constraint programming)

Expected prerequisites: Vector analysis, basic differential geometry, basic topology. These prerequisites are taught in the module *Introduction to Geometry*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Geometry Processing

Graph Drawing Algorithms

Workload for the module: 6,0 ECTS

Learning Outcomes: This module introduces efficient algorithms and complexity results for drawing and representing graphs in different visual layout styles.

Technical competencies: Students are able to

- explain fundamental concepts, structures, and problems in graph drawing,
- explain and compare different aesthetic optimization goals in graph drawing,
- design and analyze graph drawing algorithms,

- model graph drawing problems and adapt known algorithms and graph layout styles to related problems,
- implement and evaluate graph drawing algorithms, and
- investigate new graph drawing problems and develop new layout algorithms.

Non-technical competencies: Student are able to perform

- formal reasoning, correctness proofs, and proofs of computational complexity,
- structured analysis of computational geometric graph representation problems,
- modeling and solving interdisciplinary problems at the interface of application domains, information visualization, design, and graph algorithms,
- to judge trade-offs between different conflicting optimization goals, and
- being aware of possible ethical, gender, and diversity issues in the context of network visualization

Content: The module content covers fundamental and advanced topics in graph drawing including

- graph layout for restricted graph classes such as trees, planar graphs, directed graphs,
- optimization problems for different quality metrics and drawing styles in graph drawing,
- general purpose algorithms using physical analogies,
- graph drawing frameworks, and
- heuristics/approximation algorithms for NP-hard problems.

Expected prerequisites: Extended knowledge of algorithms and basics of graph theory. These prerequisites are taught in the following modules:

- *Effiziente Algorithmen*;
- *Discrete Mathematics*; and
- *Algorithmics*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Graph Drawing Algorithms

Information Visualization

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- describe the theoretical concepts of information visualization, human perception and cognition, as well as the qualitative and quantitative evaluation methods thereof,
- apply information visualization concepts in practical exercises, in combination with data science methods,
- critically evaluate information visualization algorithms, the quality of visual representations, interaction techniques, analytical methods and their interplay,
- apply perceptual and cognitive foundations and state-of-the-art visualization algorithms to information visualization design,
- select information visualization methods suitable for different data types, tasks, and users,
- apply quantitative and qualitative evaluation methods to assess the quality of information visualizations.

Non-technical competencies: In this module, students

- learn to analyze complex real-world problems by applying information visualization theory and concepts,
- learn about and analyze the application of information visualization in different domains, such as biology and engineering,
- learn to use information visualization to explain AI methods,
- work and communicate effectively in teams,
- present their analysis results.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. In particular, students learn to design and critically reflect visualizations so that they are accessible and usable by people with different backgrounds, abilities, and perspectives. This includes being mindful of biases in data collection and representation, avoiding stereotypes and cultural insensitivities, and using inclusive visual elements. The course also discusses the potential of visualization to facilitate discovery and mitigation of bias in data science applications. Furthermore, ethical aspects of visualization evaluation are discussed.

Content:

- Fundamentals of data, visualization design, and interaction design
- fundamentals of human visual perception and cognition
- Design methodology, taxonomies, and models
- Qualitative and quantitative evaluation methods
- Explainable AI
- Various application areas, like biology, and other disciplines of natural, social, and economic sciences
- Applying different methods for data preprocessing and visual inspection
- Implementation of a simple interactive information visualization tool
- Presenting visual data analysis results.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Information Visualization

Introduction to Geometry

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students can

- solve basic intersection and transformation problems in the plane and space.
- explain how projective geometry is used for rendering (projections) and image processing.
- explain and apply the most important differential operations in space.
- calculate and discuss curvature and frames of curves and surfaces in the plane and space.
- use quaternions for Euclidean transformation in space and for spherical interpolation.
- understand how to treat different surfaces according to their topology.

Content:

- Elementary Geometry (Euclidean and affine Geometry, linear / affine / convex combinations, transformations and invariants)
- Projective Geometry (homogeneous coordinates, projective transformations, central projection, quadrics)
- Vector Analysis (multivariable calculus, divergence, gradient, rotation, theorems of Stokes and Gauss)
- Differential Geometry (theory of curves and frames, geometry on surfaces)
- Geometric Algebra (quaternions, slerp, line geometry)
- Basic topology (open sets, connectedness, boundaries, metric spaces)
- Geometric topology (Euler characteristic, simplicial complexes, manifolds, Betti-numbers, fundamental groups and domains)

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Introduction to Geometry

Machine Learning for Visual Computing

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successfully completing the module, students will be able to

- understand the principles of machine learning and deep learning,
- select appropriate machine learning methods for a specific computer vision task,
- apply suitable technologies, programming frameworks, and standards to solve the task.

Non-technical competencies:

- Time management and teamwork.
- The technical foundation conveyed in this module empowers students to make informed judgments about the broader implications of machine learning technologies. It will also enable students to assess both the societal benefits and the potential for intentional misuse or unintended harm.

Content:

- Linear models with fixed basis functions and their kernel extensions, which serve as a bridge to non-parametric models (such as the Support Vector Machine or the Gaussian Process).
- Basic optimization techniques (constrained quadratic optimization, gradient descent, Newton method, backpropagation)
- Latent variable models
- Deep neural network architectures in visual computing.
- Theoretical concepts (curse of dimensionality, the bias–variance tradeoff, and theoretical bounds on the generalization error, regularization in neural networks).

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Machine Learning for Visual Computing

Media and Brain

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After completion of the module, students are able to

- recite the relevant aspects of information theory, media theory, concept theory and related fields.
- describe the relevant mathematical tools from algebra and analysis as well as logistics and are able to perform their application in practical tasks.
- explain the basics of signal processing, in particular integral transformations and machine learning with kernel-based methods and can discuss how they relate to neural processes and AI models.
- recite both the underlying theory and the application context of the above-listed methods as well as their neural equivalents in (artificial) neural networks.

Non-technical competencies: The skills relevant to the module include time management, structured working techniques, teamwork, academic writing and presentation skills. All skills are practiced in the courses of the module. Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content.

Content: Using artificial consciousness as the basic theme of the module, we explore various aspects of the human brain and of technical media processing methods that mimic the functions of the brain. Topics vary each year and include the following areas:

- Foundations: Information theory, media theory, mathematical tools, logistics
- Advanced features: Symmetry, self-similarity, etc.
- Advanced machine learning: neural networks, limits of learning, etc.
- Application of theoretical knowledge in group tasks on real-life aspects of human behavior and consciousness.

Expected prerequisites: Basic understanding of pattern recognition and its most important methods.

These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Media and Brain

Medical Image Processing and Machine Learning

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successfully completing the module, students are able to identify, explain, and differentiate the most important theories, principles, concepts, and methodologies in the fields of medical image processing and machine learning.

Their knowledge and understanding align with the latest advancements in the domain, encompassing cutting-edge techniques and applications in medical image analysis, disease detection, and prediction. In particular, they are able to:

- describe key concepts in Medical Image Processing and Machine Learning.
- name techniques for image segmentation, feature extraction, and enhancement.
- apply machine learning algorithms to medical image data.
- apply deep learning methods for disease detection and prediction in imaging.
- discuss challenges in processing and analyzing complex medical imaging data.
- integrate image processing techniques with machine learning for diagnostic support.
- solve problems in clinical and research image processing contexts.
- evaluate the effectiveness of machine learning models in medical imaging tasks.
- understand the role of AI in automating and improving medical image analysis.

Non-technical competencies: The will also be able to

- work in interdisciplinary teams and collaborate with experts in medical imaging.
- address ethical concerns related to AI and medical data privacy.

Content:

- Fundamental and advanced concepts in medical image processing and machine learning.
- Deep learning, image segmentation, and diagnostic imaging.
- Computational techniques for medical image preprocessing and feature extraction.
- Application of machine learning models to medical image analysis.
- Real-world applications in radiology, pathology, and AI-driven diagnostics.
- Design and implementation of machine learning models for medical imaging tasks.
- Evaluation of machine learning models for accuracy, reliability, and clinical relevance.

Expected prerequisites:

- Basic programming skills (e.g., Python, MATLAB, or similar).
- Fundamentals of image processing and analysis techniques.
- Introductory knowledge of medical imaging modalities (e.g., MRI, CT).
- Basic experience with machine learning algorithms and AI concepts.

These prerequisites are partly taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Medical Image Processing and Machine Learning

Medical Visualization and Visual Analytics

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successfully completing the module, students are able to identify, explain, and differentiate the most important theories, principles, concepts, and methodologies in the fields of Medical Visualization and Visual Analytics. Their knowledge and understanding align with the latest advancements in the domain, encompassing cutting-edge techniques and applications in medical data analysis and visualization. In particular, students are able:

- describe key concepts in Medical Visualization and Visual Analytics.
- list visualization techniques for medical imaging, genomics, and public health data.
- perform basic tasks in data modeling, abstraction, and computational visualization methods.
- apply AI and machine learning in medical data analysis and visualization.
- discuss challenges in neuroinformatics, bioinformatics, and epidemiological visualization.
- integrate technical expertise with biomedical domain knowledge for innovative solutions.
- solve problems in clinical and research data visualization contexts.
- evaluate visualization methods for effectiveness in diverse biomedical applications.
- understand the importance of human-in-the-loop approaches for interactive visual analytics.

Non-technical competencies: Students will work in interdisciplinary teams and collaborate with clinical and biological domain experts.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes fairness and bias in AI-driven diagnostics, representation in population health data, and inclusive design of visualization tools for diverse user groups.

Content:

- Fundamental and advanced concepts in medical visualization and analytics.
- Neuroinformatics, bioinformatics, and public health visualization.
- Computational techniques for medical data preprocessing and rendering.
- AI and machine learning in medical data analysis.
- Real-world applications in healthcare, genomics, and brain imaging.
- Design and implementation of visualization solutions for complex medical datasets.
- Evaluation of visualization techniques for accuracy, efficiency, and biomedical relevance.

Expected prerequisites:

- Fundamentals of data visualization and analysis.

The prerequisites are taught in the module *Grundlagen der Visualisierung*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Medical Visualization and Visual Analytics

Mixed Reality Lab

Workload for the module: 6,0 ECTS

Learning Outcomes: Students understand the concepts and functionality of the technologies present in the MRLab, including 3D visualization using LED walls, virtual video production, autostereoscopic displays, many-channel audio, tracking, and DMX light control. Additionally, the students are able to create software projects using these technologies.

Technical competencies: After successful completion of the module, students are able to

- understand the underlying technology, principles, and software stack for using LED walls for immersive 3D visualization and virtual production. This includes knowledge of the functionality of a marker-based tracking system, 3D stereo rendering for LED walls using Unreal Engine, and filming with a hardware-synchronized camera and interactive background, rendered on an LED wall in real time.
- use autostereoscopic 3D displays, a spatial audio system using 192 speakers, and interactive 3D light control using DMX protocol.
- identify which technology is the most appropriate for different projects in varying conditions. Additionally, students can decide on a suitable software stack based on the given project requirements.
- implement a working mixed reality project, utilizing technologies in MRLab, based on the presented theoretical knowledge.
- program and deploy an MR project using a popular game engine (e.g., Unreal Engine, Unity).

Non-technical competencies: Part of the module is group work on a mixed reality project, in which students gain skills in group cooperation, task assignment, project work, and communication. In the presentation of the project, students improve their presentation skills. Students will also be able to identify issues concerning ethics, gender, accessibility, and diversity related to mixed reality technologies. Additionally, students will be able to discuss and suggest responsible solutions regarding these ethical issues.

Content:

- Introduction to Unreal Engine
- 3D stereo visualization with tracking and interaction
- Virtual production
- Many-channel spatial sound rendering
- Rendering for autostereoscopic display
- DMX spatial light control
- Unreal Engine assignments
- Final project in group

Applied teaching and learning methods and appropriate performance assessment:

The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Mixed Reality Lab

Multimodal Interfaces

Workload for the module: 6,0 ECTS

Learning Outcomes: After successful completion of the module, students are able to:

Technical competencies:

- Create new multimodal interfaces with state-of-the-art sensors and/or actuators with suitable software and hardware control in an application.
- Understand new types of (2D/3D) interaction, including input and output devices for creating multimodal interfaces.
- Apply the methodology to design a user study to assess multimodal interfaces, from the experimental protocol to the statistical analyses of the data.
- Analyze the design, development, and evaluation of multimodal user interfaces.
- Apply the basics of statistics for assessing multimodal interfaces.

Non-technical competencies:

- Remember the basic neuroscience knowledge regarding human sensory systems and perception for improving multimodal interfaces.
- Understand the application of various multi-sensory technologies in different application areas and their implications for humans and society (rehabilitation, training, accessibility).
- Analyze Human-Robot interaction systems with diverse sensors.
- Understand ethics concerns and responsibility in complex multimodal interfaces, in particular regarding human factors for designing inclusive MMIs (e.g., gender effects, body morphologies), accessibility of multimodal interfaces to improve interaction for people with visual or locomotor impairment, and potential misuse of sensors (e.g., force feedback, voltage).

Content:

- Human sensory systems (vision, hearing, haptics, smell and taste)
- Multisensory integration, and human perception-cognition-action loop
- Multimedia Hardware: Input & Output devices for stimulating sensory systems in 2d and 3d interactions (displays, tracking, sensors...)
- How to design an experiment to assess multimedia interfaces? (experimental protocol, hypothesis, user study, statistical analyses)
- Human factors in the design of Human-Computer Interfaces, current and future challenges

Expected prerequisites: Students should have knowledge about multimedia content. Knowledge of computer graphics and user interfaces is advantageous for the lectures. Knowledge of Python and Linux command lines are advantageous for the exercise part. These prerequisites are covered in the module *Multimedia*.

Applied teaching and learning methods and appropriate performance assessment:

The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Multimodal Interfaces

Numerical Computation

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: Nach positiver Absolvierung des Moduls sind Studierende in der Lage,

- grundlegenden Konzepte algorithmisch-numerischer Lösungsmethoden zu erklären,
- kommerzieller oder frei verfügbarer numerischer Software für einen effizienten Einsatz überlegt auszuwählen,
- die vom einem Programm gelieferte Lösung auf Angemessenheit zu bewerten.

Non-technical competencies: Nach positiver Absolvierung des Moduls sind Studierende in der Lage,

- Fragestellungen von Gender, Ethik und Diversität im Kontext der Inhalte des Moduls zu identifizieren, formulieren und zu diskutieren,
- Vorgehensweisen zur Reduktion von numerischen Fehlern und ihrer Folgen sowie zum sparsamen und energieeffizienten Einsatz von Rechenleistungen anzuwenden.

Content:

- Grundlegende Fehlerbegriffe: Datenfehler, Verfahrens- oder Diskretisierungsfehler, Rundungsfehler;
- Kondition mathematischer Probleme;
- numerische Lösung linearer und nichtlinearer Gleichungssysteme;
- polynomiale Interpolation und Approximation;
- numerische Integration;
- numerische Lösung von Differentialgleichungen;
- Design und Verwendung numerischer Algorithmen bzw. numerischer Software.

Die praktische Umsetzung und Vertiefung des Stoffes der Vorlesung erfolgt in den Übungen durch (realitätsnahe) numerische Übungsbeispiele. Diese beinhalten sowohl theoretische Aufgabenstellungen, etwa was das Design oder die Analyse numerisch stabiler Algorithmen betrifft, als auch die praktische Implementierung und das Testen und Bewerten am Computer. Standardsoftware kommt zum Einsatz (z.B. Python).

Expected prerequisites: Mathematische Grundkenntnisse und Programmieren mit einer höheren Programmiersprache (z.B. Python)

Diese Voraussetzungen werden in folgenden Modulen vermittelt: *Algebra und Diskrete Mathematik, Analysis, Einführung in die Programmierung, Grundzüge digitaler Systeme*

Mandatory requirements: Studieneingangs- und Orientierungsphase.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Numerical Computation

Project in Visual Computing

Workload for the module: 6,0–12,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students can

- identify the background knowledge from Visual Computing that is required for a task.
- apply the knowledge to solve the given task.
- justify the solution scientifically.

More concretely, they will

- apply scientific analysis, design and implementation strategies (taking into account the state of the art, critical reflection of the solution)

- select suitable formal and mathematical methods for model building, abstraction, solution finding and evaluation.
- use suitable technologies, software tools and standards to solve the given task.
- thoroughly analyze the results and compare to other solutions proposed in the state of the art.
- document the results in a comprehensive and precise way.
- convincingly present the results in an interdisciplinary environment.

Non-technical competencies: Students learn to

- formulate and solve problems independently.
- present problems and solutions.
- appreciate and take into account critical comments on their work.
- judge their own limits and abilities.

The module also fosters individual creativity and innovation potential (curiosity). Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content.

Content: In this module, practical problems from the field of Visual Computing are solved. This gives insights into scientific practice and current research in Visual Computing. To tackle larger problems, two practical projects can be combined. Concretely, the work involves:

- Technical specification of a task from Visual Computing.
- Scientifically sound solution of the given task.
- Scientific documentation and discussion of the results.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module: The second project (*) is optional. Depending on the magnitude of the task, both certificates can also be awarded for completing a single, larger project.

6,0/4,0 PR Project in Visual Computing 1

* 6,0/4,0 PR Project in Visual Computing 2

Rendering

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students can

- name and describe basic and state-of-the-art methods of photorealistic rendering.

- implement offline rendering methods such as ray and path tracing, photon mapping and others
- list potential refinements for these methods

Non-technical competencies: Students learn to research literature about rendering algorithms to deepen their knowledge independently. Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes aspects such as the ethical implications of photorealistic image synthesis, the ability of reflectance and lighting models to accurately represent a diversity of real-world materials and appearances, and questions of privacy and copyright in the context of inverse and neural rendering techniques.

Content:

- Rendering theory: Basic optics, rendering equation, filtering
- Rendering algorithms: Ray tracing, path tracing, Metropolis light transport, bi-directional path tracing, (stochastic progressive) photon mapping, path space regularization, vertex connection and merging
- Acceleration techniques: Spatial hierarchies, sampling strategies
- BRDF models: Lambert, Phong, Oren-Nayar, Cook-Torrance, Ashikhmin-Shirley
- Participating media: Scattering, volumetric photon mapping, photon beams
- Higher dimensional effects: Motion blur, depth of field
- Camera models: Pinhole, Perspective, Orthographic
- Post processing: HDR, tone mapping
- Inverse and differentiable rendering
- Neural rendering

Expected prerequisites: Students should have basic knowledge of computer graphics. These prerequisites are taught in the module *Grundlagen der Computergraphik*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Rendering

Scene Understanding and Surveillance

Workload for the module: 6,0 ECTS

Learning Outcomes: After successful completion of the module, students are able to analyze and interpret multimodal image sequences, including RGB, thermal, and 3D data, for scene. Additionally, they will be equipped to address ethical and GDPR issues

in surveillance, evaluate system performance, and explore emerging techniques such as lensless imaging.

Technical competencies:

- **Understanding Multimodal Image Sequences:** Students will gain the ability to analyze and interpret multimodal image sequences, including RGB, thermal, and 3D data, to understand various sensed scenarios.
- **Application of Sensor Technologies:** Students will learn about different sensor technologies and their applications in image sequence analysis, including the advantages and limitations of using RGB, thermal, and 3D sensors.
- **Proficiency in Motion Detection and Object Tracking:** Students will acquire practical skills in motion detection and object tracking techniques, understanding their use in dynamic scenarios and video data analysis.
- **Competence in Scene Reconstruction:** Students will be able to apply scene reconstruction techniques to create 3D models and representations from image sequences, improving their understanding of spatial relationships in sensed environments.
- **Performance Evaluation:** Students will develop the ability to evaluate the performance of image analysis algorithms, understanding key performance metrics and techniques for assessing system efficiency and accuracy.
- **Event Detection in Videos:** Students will understand the methods and challenges of computer-aided event detection in videos, applying these concepts to practical scenarios.

Non-technical competencies: Students gain insights into socio-technical systems by bringing human, social, organizational, and technical elements into the design. In addition, students will:

- Understand the ethical implications of surveillance technologies, including issues related to privacy, transparency, and accountability.
- Be able to critically reflect on the societal impact of video surveillance systems.
- Learn to integrate ethical considerations into the design and evaluation of surveillance systems.
- Gain interdisciplinary perspectives through guest lectures from the social sciences or legal fields.

Content:

- Data acquisition, motion detection, tracking and scene understanding
- Surveillance from social sciences
- Excursion to a surveillance related company
- Exercises from real-world applications
- Presentations and discussions of project outcomes, techniques, and challenges

Expected prerequisites: Knowledge of computer vision and its fundamental methods. These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Scene Understanding and Surveillance

Seminar in Visual Computing

Workload for the module: 3,0 ECTS

Learning Outcomes:

Technical competencies: Students are able to

- *find literature in a selected topic:* Students conduct independent literature research using academic databases, journals, conference proceedings, and other sources relevant to Visual Computing. They critically evaluate sources for relevance, credibility, and scientific merit.
- *determine and apply an appropriate categorization for the found literature:* Students analyze the collected literature, identifying key themes, methodologies, and research directions. They develop a structured categorization scheme (taxonomies), grouping related works and highlighting connections and differences among them.
- *describe the covered research:* Students summarize and synthesize the findings from the literature, providing explanations of fundamental concepts, methodologies, and results. They discuss state-of-the-art approaches, challenges, and open research questions. Their descriptions include critical assessments of the strengths and limitations of various studies and their implications for the field of Visual Computing.

Non-technical competencies:

- Students can present their findings to a group in a structured and concise way. Students develop and deliver oral presentations that clearly communicate their literature analysis and key insights.
- They demonstrate the ability to handle audience questions thoughtfully and participate in academic discussions.
- Students submit a written report on the content of their presentation, following academic writing standards and proper practices. The report provides a comprehensive overview of the chosen topic, reflecting deep understanding and critical analysis.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes discussions on ethical implications, representation, and diversity in visual data and algorithmic design. Aspects such as bias in computer vision systems, inclusive design in AR/VR, or ethical concerns in image synthesis can be addressed depending on the chosen topic.

Content: In the seminar, students dive deeper into the literature of one chosen topic in Visual Computing (i.e., Computer Graphics, Computer Vision, Image Processing, Visualization, or Augmented and Virtual Reality) and present their findings in written and oral form.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

3,0/2,0 SE Seminar in Visual Computing

Similarity Modeling

Workload for the module: 6,0 ECTS

Learning Outcomes: Students understand how computational vision and hearing works and are able to implement such algorithms.

Technical competencies: After successful completion of the module, students are able to:

- understand the process of summarizing, classifying and evaluating media in order to solve a specific problem of media comprehension.
- name and explain the similarities and differences between different areas of media understanding. These include audio retrieval, biosignal processing, content-based image retrieval, sound analysis, face recognition, speech recognition, stock price analysis, text analysis and video processing and video surveillance.
- understand the basic theories of digital media, semantic analysis and the representation of terms and concepts.
- experiment with methods for extracting descriptions from media. In particular, they extract color, texture and object information from visual media, rhythms and harmonies from audio information and motion information from videos. They apply complex methods of spectral description of time-dependent media and local neural description of visual media with convolution operators.
- classify media descriptions in such a way that semantic descriptions (so-called categories, i.e. the terms that people use in their communication) can be derived. In addition to gaining an understanding of psychophysical correlations, students deal theoretically and practically with classical learning methods as well as state-of-the-art methods from deep learning.

- program media processing applications in today's common environments based on Python (deep learning frameworks) and Matlab (signal processing for summarizing media).

Non-technical competencies: In the module, students improve their skills in structured group work, application and understanding of artificial intelligence methods, abstraction of problems, presentation of complex scientific topics, teamwork and cooperation in course groups, and management of personal schedules and learning objectives. Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content.

Content:

- Signal processing algorithms for the analysis of digital media
- Information theory, media theory, concept theory and logistics.
- Semantic classification
- Training and application using one of the common frameworks for deep learning.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Similarity Modeling

Statistical Pattern Recognition

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- understand the notion of probability, both from a frequentist and Bayesian perspective
- understand and communicate the uncertainty of statistical estimates
- detect and avoid or remove potential sources of confounding in statistical estimates

Non-technical competencies: They will also be able to

- work together in a team
- write technical reports, including the presentation and discussion of experimental results

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content.

Content:

- Review of relevant concepts such as probability, statistical independence, correlation, regression, model selection and confounding
- Computation of statistical estimates (e.g., maximum likelihood) and communication of their uncertainty (including confidence intervals, posterior distributions, significance tests and p-values)
- Basic concepts of decision theory
- Frequentist vs. Bayesian approach to statistical inference
- Selected topics such as PCA (and applications), optimal Bayes classification for normally distributed features, and aggregation phenomena (such as Simpson paradox)

Expected prerequisites: Programming skills in a language suitable for numerical and matrix computations such Python/numpy, MATLAB or R.

These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Statistical Pattern Recognition

Video Analysis

Workload for the module: 6,0 ECTS

Learning Outcomes: This module covers techniques of video analysis and visual human motion analysis including selected applications.

Technical competencies: After successful completion of the module, students are able to:

- Understand key concepts and models of video analysis, describe how they work, and assess their relevance and applicability to a given problem.
- Evaluate selected video analysis techniques under consideration of the state-of-the-art and compare them with reference results from relevant benchmarks.
- Identify methods of human motion analysis that are suitable for a specific target application.

Non-technical competencies: This module supports the students' abilities to develop problem-solving strategies, to take responsibility in joint projects, and to improve their time management skills. Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. This includes aspects such as the proper selection of training data and test subjects to avoid bias in machine learning models and user studies.

Content: This module addresses selected problems of video analysis:

- Video acquisition
- Motion estimation and optical flow
- Video object segmentation
- 3D video
- Human motion analysis and action recognition, particularly in view of applications such as autonomous driving and human-robot interaction

Expected prerequisites: Fundamental knowledge of computer vision is highly recommended.

These prerequisites are taught in the module *Grundlagen der Computer Vision*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Video Analysis

Virtual and Augmented Reality

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to:

- understand Tracking and display technologies;
- create 3D interaction in virtual environments;
- create distributed VR/AR systems;
- apply stereo rendering techniques; and
- understand the fundamental concepts of 3D input and output for interacting in virtual environments.

Non-technical competencies: Students are able to:

- understand human perception in virtual environments (e.g., spatial understanding, human motion, embodiment, and agency);
- remember medical applications of VR/AR systems;
- analyze training and education applications with VR/AR systems; and
- understand ethical, gender, and diversity considerations in the design of VR/AR systems and 3D interactions, such as gender effects in cybersickness, human factors during immersion in virtual environments, and improving accessibility in VR/AR interfaces.

Content:

- Virtual reality and the related areas, augmented reality and mixed reality;
- Application areas and current areas of research (incl. medical applications);
- 3D graphics hardware;
- VR hardware: input and output devices: tracking and display technologies, interaction devices;
- VR software: 3D graphics toolkits and standards, user interfaces and 3D interaction;
- Psychological aspects (presence, immersion).

Expected prerequisites: Knowledge of Multimedia.

These prerequisites are covered in the module *Multimedia*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Virtual and Augmented Reality

Visualization

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to

- describe, adapt, and use advanced theoretical concepts and algorithms for visualization (e.g., scalable visual analytics approaches, advanced large-scale volume rendering and illumination),
- discuss current visualization challenges and solutions (e.g., immersive analytics, generative models for data analysis and visualization),
- program the graphics hardware for parallel data analysis and visualization (e.g., using CUDA or WebGPU),
- critically reflect advanced applications of visualization (e.g., molecular visualization, flood simulation),
- implement a visualization project using state-of-the-art visualization algorithms to interactively analyze large or complex data,
- analyze large or complex data from different domains,
- analyze the application of visualization in different domains, such as molecular biology or disaster protection.

Non-technical competencies: In this module, students learn to

- work and communicate effectively in teams,
- present algorithms and their implementation.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. In particular, the module takes accessible and usable visualization design into consideration, reiterating on the importance of biases in data collection and representation, avoiding stereotypes and cultural insensitivities, and using inclusive visual elements from basic visualization courses. Furthermore, responsible resource management for visual data analysis is discussed.

Content:

- Survey of current advances in scientific visualization, information visualization, and visual analytics
- (Real-time) visualization pipeline
- Graphics hardware programming for parallel data analysis and visualization
- Web-based visualization
- Data structures for real-time visualization
- Aggregate visualization
- Data tiles
- Progressive visualization
- Visibility management and levels of detail
- Parallel and distributed visualization
- In-situ visualization
- Out-of-core visualization
- Real-time volume illumination
- Immersive analytics
- Generative models for data analysis and visualization
- Visual text analytics
- Spatio-temporal visualization
- Molecular visualization

Expected prerequisites: Basic knowledge of visualization is highly recommended.

This knowledge can be obtained in the modules *Grundlagen der Visualisierung* or *Information Visualization*.

Applied teaching and learning methods and appropriate performance assessment: The applied teaching and learning methods must be indicated in the information system for studies and teaching for each lecture before the start of the semester; the examination modalities must also be specified.

Lectures of the Module:

6,0/4,0 VU Visualization

B Transitional provisions

1. Unless otherwise specified, the term “study” in the following refers to *master’s program Visual Computing (Studienkennzahl UE 066 932)*. The term “new curriculum” refers to the curriculum valid from Oct. 1, 2025 for this study program at the Technical University of Vienna, and “old curriculum” refers to curricula valid until then. Accordingly, “new” or “old” courses refer to those of the new or old curriculum. The term “governing body responsible for study matters” refers to the governing body responsible for master’s program Visual Computing
2. The transitional provisions apply to students who submit their degree according to the new curriculum at the Technical University of Vienna and who were enrolled at the master’s program Visual Computing at the Technical University of Vienna before July 1, 2025. The extent of the use of transitional provisions is optional for these students.
3. Upon request of the student, the governing body responsible for study matters may modify the transitional provisions individually or extend them to students not covered by Paragraph 2.
4. Certificates for courses that are equivalent in content cannot be submitted simultaneously for the degree. In case of doubt, the governing body responsible for study matters decides on the equivalence.
5. Certificates for old courses can, unless otherwise specified below, always be used for the degree if the course was completed by the student in the summer semester 2025 or earlier.
6. Excess ECTS credits from the mandatory modules may be used as a substitute for required achievements in elective modules as well as for Free Electives and/or Transferable Skills. Excess ECTS credits from the elective modules may be used as a substitute for required achievements in the Free Electives and/or Transferable Skills.
7. If, after applying the provisions of the equivalence lists, ECTS credits are missing to reach the required total of 120 ECTS credits for completing the Master’s program, these may be covered by unused courses from the elective modules and/or Free Electives and Transferable Skills to the necessary extent.
8. In the following, each course (*old* or *new*) is described by its ECTS credits (first number) and semester hours (second number), its type, and its title. The number of ECTS credits of the course actually completed is decisive.

The courses on the left side of the following table represent the old courses. On the right side, the courses are listed for which the old courses may be used. Courses listed under the same item in the equivalence lists are considered equivalent.

Alt	Neu
4,5/3,0 VU Real-Time Rendering	6,0/4,0 VU Computer Graphics
4,5/3,0 VU Visualization 2	6,0/4,0 VU Visualization
3,0/2,0 SE Seminar in Computer Graphics und/oder 3,0/2,0 SE Seminar in Computer Vision	3,0/2,0 SE Seminar in Visual Computing
2,0/2,0 VO Virtual and Augmented Reality 4,0/3,0 UE Virtual and Augmented Reality	6,0/4,0 VU Virtual and Augmented Reality
4,5/3,0 VU Computer Vision	6,0/4,0 VU Computer Vision
4,5/3,0 VU Machine Learning for Visual Computing	6,0/4,0 VU Machine Learning for Visual Computing
3,0/2,0 VU Computer Animation	6,0/4,0 VU Computer Animation and Simulation
3,0/2,0 VU Physically Based Rendering	6,0/4,0 VU Rendering
3,0/2,0 VU Modeling in Computer Graphics	6,0/4,0 VU Geometry Processing
3,0/2,0 VO Information Visualization und/oder 1,5/1,0 UE Information Visualization	6,0/4,0 VU Information Visualization
3,0/2,0 VU Visualization of Medical Data 1 und/oder 3,0/2,0 VU Visualization of Medical Data 2	6,0/4,0 VU Medical Visualization and Visual Analytics
3,0/2,0 VU Graph Drawing Algorithms	6,0/4,0 VU Graph Drawing Algorithms
3,0/2,0 VO Multimedia Interfaces und/oder 1,5/1,0 LU Multimedia Interfaces	6,0/4,0 VU Multimodal Interfaces
3,0/2,0 VO 3D Vision und/oder 3,0/2,0 UE 3D Vision	6,0/4,0 VU 3D Vision
3,0/2,0 VO Scene Understanding and Surveillance und/oder 3,0/2,0 UE Scene Understanding and Surveillance	6,0/4,0 VU Scene Understanding and Surveillance
1,5/1,0 VO Computer Vision Systems Programming und/oder 4,5/3,0 UE Computer Vision Systems Programming	6,0/4,0 VU Computer Vision Systems Programming

... Fortsetzung

Alt	Neu
3,0/2,0 VU Deep Learning for Visual Computing	6,0/4,0 VU Deep Learning for Visual Computing
3,0/2,0 VO Statistical Pattern Recognition und/oder 3,0/2,0 UE Statistical Pattern Recognition	6,0/4,0 VU Statistical Pattern Recognition
3,0/2,0 VO Medical Image Processing und/oder 3,0/2,0 UE Medical Image Processing	6,0/4,0 VU Medical Image Processing and Machine Learning
1,5/1,0 VO Video Analysis und/oder 1,5/1,0 UE Video Analysis	6,0/4,0 VU Video Analysis
3,0/2,0 VU Similarity Modeling 1 und/oder 3,0/2,0 VU Similarity Modeling 2	6,0/4,0 VU Similarity Modeling
3,0/2,0 VU Media and Brain 1 und/oder 3,0/2,0 VU Media and Brain 2	6,0/4,0 VU Media and Brain
3,0/2,0 VU Computer Numerics	6,0/4,0 VU Numerical Computation
3,0/2,0 VU Algorithmic Geometry und/oder 1,5/1,0 UE Algorithmic Geometry	6,0/4,0 VU Algorithmic Geometry
4,5/3,0 VU Algorithmic Geometry	6,0/4,0 VU Algorithmic Geometry
3,0/2,0 VU Geometry for Computer Science 3,0/2,0 VU Discrete Mathematics for Computer Science	6,0/4,0 VU Introduction to Geometry
3,0/2,0 VU Geometry for Computer Science	6,0/4,0 VU Introduction to Geometry

9. For completing the degree, either the module *Virtual and Augmented Reality* or the module *Introduction to Geometry* must be completed.

10. The following table assigns old courses without a direct correspondence in the new curriculum to one of the new modules.

Alt	Neu
3,0/2,0 VU Algorithms for Real-Time Rendering	Advanced Topics in Computer Graphics
3,0/2,0 VU Real-Time Visualization	Advanced Topics in Visualization
3,0/2,0 PR Virtual and Augmented Reality: Advanced Topics	Advanced Topics in Virtual Reality

... Fortsetzung

Alt	Neu
3,0/2,0 VU Virtual and Augmented Reality: Devices and Techniques	Advanced Topics in Virtual Reality
3,0/2,0 VU Applied Deep Learning	Advanced Topics in Computer Vision
3,0/2,0 EX Computer Vision in Industry	Advanced Topics in Computer Vision
3,0/2,0 VO Computer Vision for Cultural Heritage Preservation	Advanced Topics in Computer Vision
3,0/2,0 VU Document Analysis	Advanced Topics in Computer Vision
4,5/3,0 VU Mobile Robotics	Advanced Topics in Computer Vision
6,0/4,0 VU Machine Vision and Cognitive Robotics	Advanced Topics in Computer Vision
1,5/1,0 VO Visual Analysis of Human Motion	Advanced Topics in Computer Vision
1,5/1,0 UE Visual Analysis of Human Motion	Advanced Topics in Computer Vision
3,0/2,0 VU Stereo Vision	Advanced Topics in Computer Vision
3,0/2,0 SE Seminar on Image and Video Analysis and Synthesis	Advanced Topics in Computer Vision
3,0/2,0 VU Visual Perception for Autonomous Navigation/Cars/Robots	Advanced Topics in Computer Vision
3,0/2,0 VU Modelling of the Human Locomotor System	Advanced Topics in Computer Vision
3,0/2,0 VU Mathematical Methods of Visual Computing	Advanced Topics in Computer Graphics
3,0/2,0 VO Color	Advanced Topics in Computer Graphics

C Summary of all Mandatory Requirements in the Curriculum

Es gelten jedenfalls die in den Beschreibungen der Module in Anhang A definierten verpflichtenden Voraussetzungen.

D Semester Scheduling of the courses

It is recommended to complete the courses of the mandatory modules in the following order. Courses marked with an asterisk are recommended for the second or third semester. The third semester is recommended as a mobility semester.

1. Term (WS)

6,0 VU Computer Graphics
6,0 VU Computer Vision
6,0 VU Machine Learning for Visual Computing
6,0 VU Visualization

2. Term (SS)

6,0 VU Virtual and Augmented Reality
* 3,0 SE Seminar in Visual Computing
* 6,0 PR Project in Visual Computing 1

3. Term (WS)

* 3,0 SE Seminar in Visual Computing
* 6,0 PR Project in Visual Computing 1

E Examination Subjects with the Assigned Modules and Courses

Modules marked with an asterisk are elective modules; the remaining ones are mandatory modules.

Examination Subject “Computer Graphics”

Module “Computer Graphics” (6,0 ECTS)

6,0/4,0 VU Computer Graphics

***Module “Algorithmic Geometry” (6,0 ECTS)**

6,0/4,0 VU Algorithmic Geometry

***Module “Computer Animation and Simulation” (6,0 ECTS)**

6,0/4,0 VU Computer Animation and Simulation

***Module “Geometry Processing” (6,0 ECTS)**

6,0/4,0 VU Geometry Processing

***Module “Introduction to Geometry” (6,0 ECTS)**

6,0/4,0 VU Introduction to Geometry

***Module “Rendering” (6,0 ECTS)**

6,0/4,0 VU Rendering

***Module “Advanced Topics In Computer Graphics” (min. 3,0 ECTS)**

Examination Subject “Computer Vision”

Module “Computer Vision” (6,0 ECTS)

6,0/4,0 VU Computer Vision

***Module “3D Vision” (6,0 ECTS)**

6,0/4,0 VU 3D Vision

***Module “Computer Vision Systems Programming” (6,0 ECTS)**

6,0/4,0 VU Computer Vision Systems Programming

***Module “Medical Image Processing and Machine Learning” (6,0 ECTS)**

6,0/4,0 VU Medical Image Processing and Machine Learning

***Module “Scene Understanding and Surveillance” (6,0 ECTS)**

6,0/4,0 VU Scene Understanding and Surveillance

***Module “Video Analysis” (6,0 ECTS)**

6,0/4,0 VU Video Analysis

***Module “Advanced Topics In Computer Vision” (min. 3,0 ECTS)**

Examination Subject “Visualization”

Module “Visualization” (6,0 ECTS)

6,0/4,0 VU Visualization

***Module “Information Visualization” (6,0 ECTS)**

6,0/4,0 VU Information Visualization

***Module “Medical Visualization and Visual Analytics” (6,0 ECTS)**

6,0/4,0 VU Medical Visualization and Visual Analytics

***Module “Graph Drawing Algorithms” (6,0 ECTS)**

6,0/4,0 VU Graph Drawing Algorithms

***Module “Advanced Topics In Visualization” (min. 3,0 ECTS)**

Examination Subject “Virtual and Augmented Reality”

Module “Virtual and Augmented Reality” (6,0 ECTS)

6,0/4,0 VU Virtual and Augmented Reality

***Module “Mixed Reality Lab” (6,0 ECTS)**

6,0/4,0 VU Mixed Reality Lab

***Module “Multimodal Interfaces” (6,0 ECTS)**

6,0/4,0 VU Multimodal Interfaces

***Module “Advanced Topics in Virtual Reality” (min. 3,0 ECTS)**

Examination Subject “Machine Learning for Visual Computing”

Module “Machine Learning for Visual Computing” (6,0 ECTS)

6,0/4,0 VU Machine Learning for Visual Computing

***Module “Deep Learning for Visual Computing” (6,0 ECTS)**

6,0/4,0 VU Deep Learning for Visual Computing

***Module “Media and Brain” (6,0 ECTS)**

6,0/4,0 VU Media and Brain

***Module “Similarity Modeling” (6,0 ECTS)**

6,0/4,0 VU Similarity Modeling

***Module “Statistical Pattern Recognition” (6,0 ECTS)**

6,0/4,0 VU Statistical Pattern Recognition

Examination Subject “Methods in Visual Computing”

Module “Seminar in Visual Computing” (3,0 ECTS)

3,0/2,0 SE Seminar in Visual Computing

Module “Project in Visual Computing” (6,0–12,0 ECTS)

6,0/4,0 PR Project in Visual Computing 1

6,0/4,0 PR Project in Visual Computing 2

***Module “Numerical Computation” (6,0 ECTS)**

6,0/4,0 VU Numerical Computation

Examination Subject “Extension”

***Module “Extension” (up to 12,0 ECTS)**

3,0/2,0 VO AKGEO Computer Aided Geometric Design

1,5/1,0 UE AKGEO Computer Aided Geometric Design

6,0/4,0 VU Algorithmics

6,0/4,0 VU Heuristic Optimization Techniques

6,0/4,0 VU GPU Computing And Architectures

6,0/4,0 VU Mobile Robotics

6,0/4,0 VU Generative AI

6,0/4,0 VU Responsible Digital Ethics

6,0/4,0 VU Advanced Software Engineering

6,0/4,0 VU Efficient Programs

Examination Subject “Free Electives and Transferable Skills”

Module “Freie Wahlfächer und Transferable Skills” (9,0 ECTS)

Examination Subject “Diploma Thesis”

1,5/1,0 SE Seminar für Diplomand_innen

27,0 ECTS Diplomarbeit

1,5 ECTS Kommissionelle Abschlussprüfung

F Elective Catalog “Transferable Skills”

The courses to be chosen within the module *Freie Wahlfächer und Transferable Skills* from the topic area “Transferable Skills” may be selected, among others, from the following catalog.

- 3,0/2,0 SE Coaching als Führungsinstrument 1
- 3,0/2,0 SE Coaching als Führungsinstrument 2
- 3,0/2,0 SE Didaktik in der Informatik
- 1,5/1,0 VO EDV-Vertragsrecht
- 3,0/2,0 VO Einführung in die Wissenschaftstheorie I
- 3,0/2,0 VO Einführung in Technik und Gesellschaft
- 3,0/2,0 SE Folgenabschätzung von Informationstechnologien
- 3,0/2,0 VU Forschungsmethoden
- 3,0/2,0 VO Frauen in Naturwissenschaft und Technik
- 3,0/2,0 SE Gruppendynamik
- 3,0/2,0 VU Kommunikation und Moderation
- 3,0/2,0 SE Kommunikation und Rhetorik
- 1,5/1,0 SE Kommunikationstechnik
- 3,0/2,0 VU Kooperatives Arbeiten
- 3,0/2,0 VU Präsentation und Moderation
- 1,5/1,0 VO Präsentation, Moderation und Mediation
- 3,0/2,0 UE Präsentation, Moderation und Mediation
- 3,0/2,0 VU Präsentations- und Verhandlungstechnik
- 4,0/4,0 SE Privatissimum aus Fachdidaktik Informatik
- 3,0/2,0 VU Rhetorik, Körpersprache, Argumentationstraining
- 3,0/2,0 VU Softskills für TechnikerInnen
- 3,0/2,0 VU Techniksoziologie und Technikpsychologie
- 3,0/2,0 VO Theorie und Praxis der Gruppenarbeit
- 3,0/2,0 VO Zwischen Karriere und Barriere

G Innovation Supplementary Program

Students who wish to apply the competencies acquired in the master's program to founding a startup, managing a company, or participating in university projects can acquire the additional skills required for these activities through the supplementary program *Innovation*, which can be completed alongside the master's program.

The (additional) workload for the English-language supplementary program *Innovation* amounts to 30 ECTS credits (equivalent to one semester). The completion of the supplementary program *Innovation* can also take place after finishing the master's program.