



TECHNISCHE
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WIEN

Bachelor

Master

Doctorate

Postgraduate

Curriculum
for the

Master's program
Medical Informatics
UN 066 601

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§1 Foundation and Scope

The present curriculum defines and regulates the Master’s program *Medical Informatics* in ingenieur Sciences—called “Medizinische Informatik” in the performance agreements and in the cooperation agreement signed in January 2026—, which is carried out together at the Technical University of Vienna and Medical University 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) –, the Study Law Provisions of the Statutes of the two universities and the mentioned cooperation agreement. The program has been structured and designed in alignment with the qualification profile, as detailed in §2.

§2 Qualification Profile

Medical Informatics focuses on integrating information technologies into healthcare to drive innovation, improve treatment outcomes, and support the digital transformation of healthcare. This interdisciplinary field combines knowledge from computer science, medicine, biology, public health, and related disciplines to develop and implement innovative solutions.

The Master’s programme *Medical Informatics* provides a sound, scientifically and methodologically rigorous education in these areas, with a focus on sustainable knowledge. This enables graduates to pursue careers in the following fields and further qualifications, particularly through a subsequent doctoral programme, and makes them internationally competitive:

- Designing and implementing innovative solutions in digital health and medical informatics
- Applying state-of-the-art techniques in data analysis, modelling, and machine learning
- Solving complex interdisciplinary IT problems in healthcare
- Conducting research in academic and industrial settings, focusing on health technologies and medical informatics
- Leading healthcare IT projects and implementing digital transformation strategies in clinical and public health
- Advising and training stakeholders on digital health solutions and innovations

The Master’s programme *Medical Informatics* emphasises a methodological approach to problems and the associated solution-oriented way of thinking. The combination of fundamental medical knowledge with scientific working methods and practical technical skills enables graduates to develop innovative solutions at the intersection of computer science and medicine and to acquire broad interdisciplinary expertise. The focus is on developing and applying algorithms, data-processing workflows, interoperable information systems, and decision-support systems that enable evidence-based and data-driven healthcare.

In addition to comprehensive preparation for addressing IT problems in medicine, students receive advanced training in a self-selected specialisation. Depending on their chosen profile, they acquire the skills to design solutions, develop systems, and implement new analytical methods in close collaboration with biologists, neuroscientists, physicians, and healthcare professionals, integrating these into research, clinical work, and healthcare processes.

By teaching fundamental concepts of medical informatics, the programme prepares graduates for current and future tasks in biomedical research, medicine, and healthcare and provides a solid foundation for efficiently developing new methods in medical informatics.

Graduates also acquire competencies in diversity and gender medicine and are able to consider the relationship between the core dimensions of diversity (socioeconomic status, ethnic and national origin, age, physical and mental abilities, sexual orientation, gender and gender identity, religion, and worldview) and health status in the context of medical informatics.

Career fields for graduates include:

- Pharmaceuticals and personalised medicine (bioinformatics, drug discovery)
- Neuroscience (neuroinformatics, brain imaging data analysis)
- Public health (epidemiological data analysis, public health informatics)
- Mobile and wearable health technologies (assistive devices, health monitoring)
- Artificial intelligence in healthcare (predictive analytics, diagnostics, treatment optimisation)
- Biomedical research (genomics, proteomics, imaging technologies)
- Health data management: handling, integrating, and securing large healthcare datasets.

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

Technical competencies Students may choose the following specialisations within the Master's programme *Medical Informatics*: bioinformatics, neuroinformatics, public health informatics, mobile and wearable health technologies, or artificial intelligence and analytics in clinical informatics. Each specialisation provides specific competencies:

- Bioinformatics: Techniques for managing and analysing biological data with computational tools in genomics, proteomics, and personalised medicine.
- Neuroinformatics: Techniques for simulating neural networks and managing and analysing complex neuroscientific data to understand brain functions and diseases.
- Public health informatics: Techniques for managing and analysing public health data, including epidemiological studies and population health management, and for supporting public health decisions.
- Mobile and wearable health technologies: Designing and developing innovative digital health tools for patient care and health monitoring.

- Artificial intelligence and analytics in clinical informatics: This field combines AI-based analytics, medical imaging, and clinical informatics to use data from imaging procedures and clinical systems effectively. The aim is to support evidence-based decisions and improve diagnostics, workflows, and patient outcomes.

Transversal competencies

- Applying scientific and computational methods to solve problems in healthcare.
- Using computational tools to simulate, improve, and optimise biological systems and healthcare procedures.
- Planning and conducting experiments, analysing data, interpreting results, and evaluating solutions.
- Knowledge of software tools, programming languages, and healthcare standards.
- Collaborating with professionals from medicine, biology, public health, and technology.
- Documenting and presenting complex solutions to diverse audiences, including scientists, clinicians, and policymakers.
- Leading interdisciplinary teams and contributing effectively as a team member.
- Assessing the societal and ethical impacts of digital health innovations.
- Managing time, resources, and priorities to achieve project goals while taking responsibility for one's own work.
- Fostering creativity and curiosity while developing innovative solutions to complex healthcare challenges.
- Adapting to and engaging in lifelong learning about new trends and technologies in digital health.
- Strategic thinking and planning.

§3 Time and effort

The workload for the Master's program *Medical Informatics* 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 degree programme is academically relevant if at least 120 ECTS have been completed in a technical field such as computer science, mathematics, electrical engineering, biomedical engineering, or a similar field, including at least

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

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 up to a maximum of 4,5 ECTS in *Freie Wahlfächer und Transferable Skills* as free electives, but not as transferable skills.

Graduates of Bachelor's programmes in the field of computer science at Austrian universities are admitted without supplementary examinations.

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 two Rectorates.

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.

The language of instruction is English. Admission to the Master's program *Medical Informatics* requires English proficiency. Applicants whose first language is not English must provide proof of the required language skills at admission.

English proficiency is considered demonstrated under Section 63 (10) UG by the following evidence:

1. Successful completion of the school-leaving examination in English at a school in a Member State of the European Union or the European Economic Area, Switzerland, the United Kingdom of Great Britain and Northern Ireland, the United States, Australia, New Zealand, or Canada.
2. Completion of a programme of study lasting at least three years and taught in English at a recognised Austrian or foreign post-secondary educational institution, provided that the institution is located in a Member State of the European Union

or the European Economic Area, Switzerland, the United Kingdom of Great Britain and Northern Ireland, the United States, Australia, New Zealand, or Canada.

3. Cambridge Certificate in Advanced English (CAE): Level B2 result (at least 160 points).
4. Cambridge English First Certificate (FCE): grade C or higher (at least 160 points).
5. TOEFL iBT (internet-based): at least 87 points.
6. IELTS Academic: overall band score of at least 6.5.
7. Language proficiency certificate from a university language centre demonstrating at least level B2 of the Common European Framework of Reference for Languages, issued by a university in a Member State of the European Union or the European Economic Area, Switzerland, the United Kingdom of Great Britain and Northern Ireland, the United States, Australia, New Zealand, or Canada.
8. An IB Diploma issued under the regulations of the International Baccalaureate Organization, provided that it includes English as a school subject with a grade of at least 5.
9. Successful completion of the supplementary examination in English at a preparatory programme at an Austrian university.
10. Successful completion of an English examination as part of a university entrance qualification examination at an Austrian university.

Certificates under items 3) to 7) are accepted for two years from the examination date. Older certificates are no longer sufficient proof. Certificates under items 1), 2), and 8) to 10) are valid indefinitely.

Some elective courses may be offered in German. German proficiency at level B1 of the Common European Framework of Reference for Languages is recommended for these courses.

§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 *Medical Informatics* consists of the following examination subjects and their assigned modules. Modules marked with an asterisk (*) are *elective* modules; the others are *mandatory* modules. The mandatory modules must be completed. In the mandatory and elective modules, excluding *Freie Wahlfächer und Transferable Skills*, courses worth at least 81 ECTS must be completed. At least 24 ECTS of these must be selected from one of the specialisations listed below. In *Freie Wahlfächer und Transferable Skills*, students must complete enough courses so that, together with the Master thesis and courses selected in the other mandatory and elective modules, the total amounts to at least 120 ECTS. If more than 81 ECTS are completed in the other mandatory and elective modules, fewer ECTS may be completed in this module by the same amount, but at least 4,5 ECTS in transferable skills must be completed.

In overview, the Master's programme *Medical Informatics* is structured as follows:

- Courses: 90 ECTS
 - Mandatory modules: 39 ECTS
 - * Foundations: 30 ECTS
 - * Seminar: 3 ECTS
 - * Project: 6 ECTS
 - Elective modules: 42 ECTS
 - * At least 24 ECTS selected from one specialisation
 - Free electives and transferable skills: 9 ECTS
 - * At least 4.5 ECTS in transferable skills
- Master's thesis: 30 ECTS

Foundations of Medical Informatics (30 ECTS)

Advanced Software Engineering in the Biomedical Context (6,0 ECTS)

Biological Basis of Disease (6,0 ECTS)

Introduction to Medical Data Science and Analytics (6,0 ECTS)

Introduction to Digital Health (6,0 ECTS)

Practice of Medicine (6,0 ECTS)

Biological and Medical Principles

*Bioinformatics (6,0 ECTS)

*Computational Neuroscience (6,0 ECTS)

*Introduction to Molecular Biology (6,0 ECTS)

*Introduction to Neuroscience (6,0 ECTS)

*Neuroinformatics (6,0 ECTS)

*Prosthetics and Control Theory (6,0 ECTS)

Data, Policy, and Health Informatics

- *Advanced Database Systems (6,0 ECTS)
- *AI Ethics (6,0 ECTS)
- *Data Stewardship (6,0 ECTS)
- *Methodological Foundations of Public Health Informatics (6,0 ECTS)
- *Public Health Policy and Healthcare Management (6,0 ECTS)
- *Responsible Digital Ethics (6,0 ECTS)
- *Standardized Health Information Management (6,0 ECTS)

Machine Learning and Intelligent Health Systems

- *Advanced Machine Learning in Healthcare (6,0 ECTS)
- *Medical Signal Processing and Imaging (6,0 ECTS)
- *Computer Vision (6,0 ECTS)
- *Generative AI, General AI (6,0 ECTS)
- *Logic-based Artificial Intelligence (6,0 ECTS)
- *ML in Medical Imaging and Precision Medicine (6,0 ECTS)
- *Modeling and Simulation for Medical Informatics (6,0 ECTS)

Human-Centered Technologies and Visualization in Healthcare

- *Artifact-based Design (6,0 ECTS)
- *Assistive Technologies (6,0 ECTS)
- *Human-Centered AI (6,0 ECTS)
- *Information Visualization (6,0 ECTS)
- *Medical Visualization and Visual Analytics (6,0 ECTS)
- *Virtual and Augmented Reality (6,0 ECTS)
- *Wellbeing Technologies (6,0 ECTS)

Free Electives

Freie Wahlfächer und Transferable Skills (9,0 ECTS)

Seminar, Project, and Advanced Topics in Medical Informatics

- Seminar in Medical Informatics (3,0 ECTS)
- Project in Medical Informatics (6,0 ECTS)
- *Advanced Topics In Medical Informatics (min. 3,0 ECTS)

Master's thesis

See Section § 9.

Specialisation

To support a coherent selection from the modules defined in the examination subjects, five specialisation areas are available, combining modules from those subjects. Students must choose one specialisation and complete courses worth at least 24 ECTS from the modules listed for it. Modules without an asterisk (*) provide the foundations of a specialisation, so students are advised to complete them first.

Bioinformatics

Bioinformatics

Introduction to Molecular Biology

- * Advanced Machine Learning in Healthcare
- * Medical Visualization and Visual Analytics
- * ML in Medical Imaging and Precision Medicine
- * Modeling and Simulation for Medical Informatics

Neuroinformatics

Introduction to Neuroscience

Neuroinformatics

- * Advanced Machine Learning in Healthcare
- * Medical Signal Processing and Imaging
- * Computational Neuroscience
- * Medical Visualization and Visual Analytics
- * ML in Medical Imaging and Precision Medicine

Public Health Informatics

Methodological Foundations of Public Health Informatics

Public Health Policy and Healthcare Management

- * Advanced Machine Learning in Healthcare
- * Data Stewardship
- * Generative AI, General AI
- * Modeling and Simulation for Medical Informatics
- * Standardized Health Information Management

Mobile Health, Wearable, and Assistive Technologies

Assistive Technologies

Wellbeing Technologies

- * Artifact-based Design
- * Prosthetics and Control Theory
- * Responsible Digital Ethics
- * Standardized Health Information Management

AI and Analytics in Clinical Decision Making

Medical Visualization and Visual Analytics
ML in Medical Imaging and Precision Medicine

- * Advanced Machine Learning in Healthcare
- * AI Ethics
- * Medical Signal Processing and Imaging
- * Generative AI, General AI
- * Human-Centered AI
- * Logic-based Artificial Intelligence

Brief description of the modules

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

Advanced Database Systems (6,0 ECTS) Databases are at the heart of virtually every software system. However, there are many different database system technologies and the choice depends on the requirements of the concrete application. In this module, various such technologies are put to work – including classical relational database systems, NoSQL systems, and systems specifically designed for distributed data processing in a cluster.

Advanced Machine Learning in Healthcare (6,0 ECTS) This module conveys current machine learning (ML) approaches that are particularly relevant in medicine, using practical examples and current research trends. The focus is on modern methods that support clinical decision-making, personalized therapy planning, and biomedical research — from robust prediction models to probabilistic and causal methods, as well as distributed and privacy-preserving learning. Students learn which ML methods are suitable for different types of medical data (e.g., clinical routine data, imaging, omics, molecular and protein data), what assumptions underlie them, and how models can be validly and responsibly evaluated.

Advanced Software Engineering in the Biomedical Context (6,0 ECTS) The development of software systems — including open source software — to support and improve processes in the biomedical context (particularly medical diagnosis or therapeutic processes, which often turn the software into medical devices) is a multidisciplinary group task in agile or plan-driven projects. This course provides the framework in which student groups practice the interaction between (i) a Software Product Owner role with a background in a biomedical domain and (ii) an advanced Software Engineering team in a project. The result is software prototypes and documentation that would be useful and usable for real users in the biomedical domain.

Advanced Topics In Medical Informatics (min. 3,0 ECTS) This module provides a placeholder for current topics in Medical Informatics to account for rapid developments and changes in this field. The specific contents may change each year; corresponding proposals are evaluated by the study program management or curriculum direction.

AI Ethics (6,0 ECTS) With the rapid developments in Artificial Intelligence (AI), we find an inevitable increase in AI's impact on our lives, posing various ethical challenges for developers, policy-makers, and society at large. This has led to a general awareness that AI systems must be aligned with human values, ethics, and laws. This module introduces various ways in which ethics and AI meet. It enables students to develop basic skills for identifying and critically reflecting on AI-specific ethical challenges, and for incorporating critical thinking on these topics in their work and further studies.

Artifact-based Design (6,0 ECTS) By engaging in hands-on prototyping, testing, and iterative design, students will develop skills in designing and implementing tangible and digital artifacts that reflect user needs and societal contexts. Through lectures, collaborative projects, and reflective critiques, participants will learn to develop artifacts as tools for understanding problems, communicating ideas, and evaluating concepts. This module emphasizes a practical, research-oriented approach to design, enabling students to translate theoretical knowledge into meaningful and impactful integrated physical-digital concepts.

Assistive Technologies (6,0 ECTS) This module deals with the general principles and applied methods of assistive technologies (AT) that are prerequisite for being able to offer and make devices, systems and services available to disabled and elderly people in an appropriate manner. It covers the basic knowledge required to create a general barrier-free ICT landscape designed according to the principles of universal design, and to develop special solutions to support and promote disabled and elderly people. Students should be interested in the social implications of computer science and have a basic knowledge of anatomy and physiology (high school level). After completing this module, students will have a comprehensive overview of the field of assistive technologies in general, its practical application (assistive systems) and the sub-field of web accessibility), which is particularly important for students of this module, with the theoretical knowledge being deepened in practical exercises and case studies.

Bioinformatics (6,0 ECTS) This module teaches the fundamentals of bioinformatics, the essential algorithms used for analyzing -omics data, and the basics of implementing results in practice. It forms the foundation for understanding bioinformatics analysis methods and their relationship to medicine, and provides students with the tools to investigate cellular biological processes using the most modern analysis methods.

Biological Basis of Disease (6,0 ECTS) This module teaches the essential biological foundations of the human body and the main causes and changes that trigger diseases (general pathology). It forms the foundation for understanding medically relevant physiological and pathological processes. It bridges the gap from structure to function to dysfunction to human disease.

Computational Neuroscience (6,0 ECTS) This module covers topics in the field of Computational Neuroscience, including fundamental theories, central mathematical concepts for analyzing structural and functional connectivity, the use of Machine Learning for neuroimaging processing, and practical algorithms. Core topics include: neuroimaging techniques, morphometric brain analysis, preprocessing of brain signals and graph-based

evaluations, Brain-Atlas-Learning, structural connectivity and tractography techniques, Graph Convolutional Neural Networks, LLMs, and deep learning agents for computer-assisted brain analysis, fetal brain development, plasticity, and functional reorganization.

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.

Data Stewardship (6,0 ECTS) Data plays an increasingly important role, both in research as well as in industry applications. This module focuses on data and its processing, ensuring that it meets quality requirements of the respective types of use. This module further provides knowledge on the life cycle of data, from data collection to long-term provision and reuse as well as the correct management of sensitive data.

Generative AI, General AI (6,0 ECTS) This module offers a comprehensive introduction to universally applicable ("general purpose") AI systems with a focus on Large Language Models, AI agents, and their transformative potential. Biomedical applications serve as concrete illustrations throughout. Students acquire both conceptual understanding and practical skills in working with leading ("frontier") AI systems. The module covers how these systems work, how to evaluate and effectively use them, and how to think critically about their broader implications for science, medicine, and society.

Human-Centered AI (6,0 ECTS) This module provides foundational knowledge of user interfaces, "human in the loop" systems, and artificial intelligence, including supervised and unsupervised learning, as well as reinforcement learning. Students will explore key domains of human-AI interaction, such as recommender systems, chatbots, intelligent text entry, explainable AI, user modeling, and personalized and adaptive user interfaces.

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 Medical Data Science and Analytics (6,0 ECTS) This module introduces the fundamentals of Data Science in medicine from two different perspectives: (a) the statistical view of data modeling, and (b) the fundamental aspects of Machine Learning (ML).

Introduction to Digital Health (6,0 ECTS) This module provides an introduction and overview of the essential application areas of informatics in medicine, from the requirements of medical documentation to electronic health records, digital therapeutics,

and robotics in care and surgery. As a mandatory module, it thus provides the basis for all in-depth modules in the different specialization areas.

Introduction to Molecular Biology (6,0 ECTS) This module teaches the fundamentals of human cellular metabolism, molecular genetics, and cellular signal transduction. It thus provides the basic knowledge needed to understand and perform bioinformatics analyses of the cellular proteome, metabolome, genome, transcriptome, and signalosome.

Introduction to Neuroscience (6,0 ECTS) This module offers an introduction to all levels of the human nervous system – from molecular foundations to pathophysiological and diagnostic aspects. It covers molecular and cellular foundations of neurophysiology, an overview of neuroanatomy, neurophysiology, neuropharmacology, and neurogenetics, as well as an introduction to the International Classification of Diseases (ICD) using selected examples. The seminar serves to deepen selected topics and examine selected data types in the context of project work.

Logic-based Artificial Intelligence (6,0 ECTS) This module provides an advanced introduction to logic-based artificial intelligence. The students will learn selected logic formalisms used to represent complex domains of interest and the computational methods for deriving conclusions from these representations. By discussing both theoretical principles and practical techniques, the module aims to prepare students for advanced applications and research in AI. The module begins by introducing predicate logic as a specification language, and then moves on to description logics (DL) for representing ontological knowledge. The students will learn the basics of DL reasoning; special attention will be given to the description logic EL popular in biomedical informatics. The students will learn the principles behind nonmonotonic reasoning, and become acquainted with answer-set programming and its application for declarative problem solving in combinatorial domains. Students will learn the foundations of probabilistic reasoning and, finally, rule learning, bridging the gap between logical inference and data-driven learning. By the end of the module, students will have developed both theoretical expertise and practical skills, enabling them to deploy logic-based AI solutions to solve problems in different domains.

Medical Signal Processing and Imaging (6,0 ECTS) This module provides the basic knowledge and skills for processing and analyzing signal and image data in medicine. The former includes electrophysiological signals such as electrocardiography (ECG) or electroencephalography (EEG), signals from other technical recording methods such as photoplethysmography or respiratory measurement. The latter includes, among others, radiological methods such as computed tomography (CT), magnetic resonance tomography (MRI), X-ray, ultrasound imaging, as well as other imaging methods such as optical coherence tomography (OCT), photographic images, or high-resolution microscopy methods used in other medical fields. In addition to the essential steps for generating and acquiring such data, the specific problems associated with the use of biosignals and medical image data in modern medicine are addressed, as well as their solutions in the form of presentations of current methods of digital signal and image analysis techniques.

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.

Methodological Foundations of Public Health Informatics (6,0 ECTS) This module teaches the essential methodological foundations for addressing questions in Public Health Informatics and health services research in an evidence-based manner. It combines Outcomes Research — with a focus on the operationalization of outcome and quality measures and their implementation in usable decision support (e.g., dashboards) — with a comprehensive introduction to epidemiology from medical and methodological-statistical perspectives. Students learn to correctly define outcomes, quality indicators, and population-related measures, critically assess data quality and biases, and apply appropriate statistical methods (especially regression models) for the analysis of healthcare and population data. This enables them to robustly interpret results and prepare them comprehensibly for clinical, organizational, and public health decisions.

ML in Medical Imaging and Precision Medicine (6,0 ECTS) This module teaches central concepts and methods of Deep Learning (DL) for medical image analysis and precision medicine applications. Students learn to implement complete DL workflows from data preparation and preprocessing through model training and validation to interpretation, explainability, and uncertainty estimation, and to select suitable methods for different imaging modalities. In terms of content, the module spans from classical ML approaches to modern architectures such as CNNs or Transformers. Another focus is on robustness, generalization, domain adaptation, as well as ethical issues such as bias, fairness, and responsible clinical translation.

Modeling and Simulation for Medical Informatics (6,0 ECTS) This module provides an introduction to modeling and simulation and their application in medicine and public health. It includes an introduction to the modeling approaches of system dynamics, discrete event simulation, cellular automata, agent-based modeling, Markov modeling, as well as modeling and simulation with difference and differential equations. It explains how such models are generally designed and implemented in different programming environments. The module focuses on the application of these methods in the medical field, particularly in health technology assessment. It introduces the methodological approaches when evaluating medical interventions and how simulation is used to examine their impact on health outcomes.

Neuroinformatics (6,0 ECTS) The goal of this course is to teach students fundamental concepts and methodological tools to conduct research in neuroinformatics – a field that deals with building neural network models of brain activity to explain the nature of intelligent tasks and behaviors. The first part of the course addresses the implications of such models for neuroscience research, particularly for understanding motor skills, cognition, and learning. The second part focuses on translational research, particularly on models that achieve state-of-the-art performance in neural decoding and in controlling

Brain-Machine Interfaces. The third part discusses how modeling biological computation in the brain contributes to the advancement of Machine Learning algorithms and what opportunities arise for the integration of biological and artificial computation.

Practice of Medicine (6,0 ECTS) This module provides a comprehensive introduction to clinical practice and daily medical routines, specifically tailored to the requirements of Medical Informatics. It bridges the gap between technological developments and their applications in healthcare by providing a deep understanding of clinical workflows, medical terminology, and the processes of medical decision-making.

Project in Medical Informatics (6,0 ECTS) In this module, practical problems from the field of Medical Informatics are solved. The work provides insights into scientific practice and current research in Medical Informatics.

Prosthetics and Control Theory (6,0 ECTS) This module provides an in-depth introduction to the fields of exoprosthetics, electrostimulation, neuroprosthetics, and medical control engineering. In the spirit of interdisciplinary competence acquisition, medical, therapeutic, and technical fundamentals from these fields are taught and linked with specific application cases in medical informatics, and deepened through practical exercises.

Public Health Policy and Healthcare Management (6,0 ECTS) This module conveys central concepts and instruments of public health policy as well as health care management. The focus is on the design and control of health systems, decision-making processes in politics and administration, as well as the organization and management of health organizations. Students learn how health policy goals (e.g., access, quality, efficiency, and equity) are formulated and translated into programs, structures, and processes. At the same time, they acquire an understanding of management and organization theories and their application in the health sector — including the role of management and clinical information systems (MIS/CIS) and other information technologies as support for planning, coordination, control, and evaluation.

Responsible Digital Ethics (6,0 ECTS) This module addresses the critical importance of responsible digital ethics in the age of pervasive digital systems and increasing regulatory requirements. Students explore foundational concepts such as trust, fairness, accountability, digital rights, and ethical design principles. Through lectures, interactive seminars, and student-led activities, participants engage with real-world challenges and diverse literature to develop a nuanced, experiential understanding of digital ethics and their role in fostering ethical digital practices.

Seminar in Medical Informatics (3,0 ECTS) In the seminar, students dive deeper into the literature of one chosen topic in Medical Informatics (e.g., Bioinformatics, Neuroinformatics, Public Health Informatics, etc.) and present their findings in written and oral form.

Standardized Health Information Management (6,0 ECTS) This module provides an introduction to fundamental standards in Medical Informatics. A special focus is

placed on standards in the areas of (i) Electronic Health Records, (ii) federated analysis of health data, and (iii) medical imaging data.

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.

Wellbeing Technologies (6,0 ECTS) This course explores the design and evaluation of technologies that promote wellbeing and a healthy lifestyle. Students learn theoretical foundations of wellbeing, personal informatics, and physical activity, and gain hands-on experience in designing and prototyping interfaces that foster wellbeing. The course incorporates an ethics component, focusing on the responsibilities of designers working with health-related technologies, and addresses the challenges of creating technologies that support positive behaviour change. Through interactive lectures and workshops, participants work with sports sensors, motion tracking, and physiological sensing to develop and evaluate technologies aimed at enhancing quality of life. The course is highly design-driven, emphasising practical application and showcasing numerous examples.

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.

§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 and MedUni Wien

As a general rule, the study and examination regulations of the university offering the respective course shall apply to all courses and examinations within this degree programme. The following provisions shall apply:

- The scope of the course must be specified in ECTS credits and semester hours.
- Courses can be held as “block courses”.
- Course exams serve as proof of the learning outcomes conveyed by an individual course.
- Course exams must be conducted by the course instructor. If necessary, the governing body responsible for study matters can appoint another suitable examiner.
- Exams can be conducted at the beginning and end of non-teaching periods.
- Exam dates must be announced in an appropriate manner.

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.

PR (Project (TU Wien)/Praktikum (Meduni Wien): 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.

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 or Course Catalogue

- 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:
 - Prerequisites
 - 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. For the supervision, submission, and assessment of the Master's thesis, as well as for the completion of the final examination before an examination board (Defensio), the regulations of the university to which the Master's thesis supervisor is affiliated or at which the Master's thesis is registered shall apply. The same shall apply to the publication of the Master's thesis; i.e., the university to which the Master's thesis supervisor is affiliated shall be responsible for the publication of the Master's thesis pursuant to Section 86 of the Universities Act (UG). The final examination before an examination board shall be conducted orally before an examination panel. The exam 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 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 of the respective modules, 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 course. 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 *Medical Informatics* 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 B.

The assessment and attendance modalities for courses of types UE, PR, VU, and SE 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 or in the course catalogue 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).

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.

Kommt es in einer Lehrveranstaltung ohne explizit geregelte Platzvergabe zu einem unvorhergesehenen Andrang, kann die Lehrveranstaltungsleitung in Absprache mit dem studienrechtlichen Organ Teilnahmebeschränkungen vornehmen. Studierende, die zum Masterstudium *Medical Informatics* zugelassen sind und für die eine Nichtteilnahme zu einer Studienzeitverzögerung führen könnte, werden in jedem Fall aufgenommen. Die Vergabe der allenfalls übrigen Plätze ist nach folgenden Kriterien (mit absteigender Priorität) zu regeln.

- Es werden jene Studierenden bevorzugt aufgenommen, die die formalen und inhaltlichen Voraussetzungen erfüllen. Die inhaltlichen Voraussetzungen können etwa an Hand von bereits abgelegten Prüfungen oder durch einen Eingangstest überprüft werden.

- Unter diesen hat die Verwendung der Lehrveranstaltung als Pflichtfach Vorrang vor der Verwendung als Wahlfach und diese vor der Verwendung als Freifach.
- Innerhalb dieser drei Gruppen sind jeweils jene Studierenden zu bevorzugen, die trotz Vorliegens aller Voraussetzungen bereits in einem früheren Abhaltesemester abgewiesen wurden.

Die Studierenden sind darüber ehebaldigst zu informieren.

§ 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 *Medical Informatics* are awarded the academic degree "Diplom-Ingenieur"/"Diplom-Ingenieurin" – abbreviated as "Dipl.-Ing." or "DI" (abbreviated as "Master of Science"). according to §54 Abs. 1 UG

§ 11 Entry into Force

This curriculum enters into force on 1 October 2026 and applies to all students commencing the Master's program *Medical Informatics* from the winter semester 2026 onwards.

A Module Descriptions

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

“Workload” “Course Title” (“University to which the course is assigned”), e.g. 6.0/4.0 VU Advanced Database Systems (TUW)

The first number indicates the number of ECTS credits assigned to the course, and the second indicates the number of semester hours. ECTS credits are a measure of students’ workload, with one academic year comprising 60 ECTS credits and one ECTS credit corresponding to 25 hours of 60 minutes each. One semester hour corresponds to as many teaching units as there are teaching weeks in the semester. One teaching unit lasts 45 minutes. The respective course type is explained in detail in Section §6 under *Course Types* on page 18. The university to which the course is assigned is indicated in parentheses (TUW = TU Wien, MUW = Medical University of Vienna). If no university is indicated in parentheses, the course is assigned to both universities.

Advanced Database Systems

Workload for the module: 6,0 ECTS

Learning Outcomes: This module deals with different database system technologies - including classical relational database systems, NoSQL systems, and systems specifically designed for distributed data processing in a cluster.

Technical competencies: After successful completion of the module, students

- can use advanced features and extensions of relational data management such as recursion, stored procedures and triggers, object-orientation and graphs,
- know central “big data” concepts, methods, technologies, and subject-specific terminology,
- are able to use distributed data processing methods such as MapReduce and Spark,
- can name basic principles of NoSQL systems,
- are able to use various NoSQL technologies.

Non-technical competencies: Students acquire the ability to understand different paradigms underlying database system technologies and choosing and managing an appropriate one for a given application. 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: The course covers three major topics:

- Advanced features and extensions of relational data management,
- Introduction to distributed data processing techniques (with a focus on MapReduce and Spark),
- Basic principles of various NoSQL systems.

Expected prerequisites: Basic knowledge of “Database Systems”, “Algorithms and Data Structures”, and “Programming”

These prerequisites are taught in the following modules:

- Database Systems (*Datenbanksysteme*),
- Algorithms and Data Structures (*Algorithmen und Datenstrukturen*),
- Programming (*Einführung in die Programmierung*).

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 Advanced Database Systems

Advanced Machine Learning in Healthcare

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- explain, compare, and select advanced ML approaches for medical applications in a targeted manner
- translate medical problem formulations into suitable ML formulations and derive appropriate data representations.
- design and methodically evaluate clinical and biomedical models (validation strategies, metrics, generalization, robustness, uncertainty, data leakage, bias).
- apply and classify modern model classes for specific domains
- justify concepts for privacy-preserving and cross-site modeling and discuss their limitations.
- critically assess the benefits of synthetic data and simulations (e.g., Digital Twins), including typical risks such as distribution shifts, artifacts, and lack of clinical validity.

Non-technical competencies: In addition, students develop competencies to design ML systems in the medical context in a responsible, traceable, and interdisciplinary manner. They can identify ethical, legal, and societal aspects (data protection, fairness/bias, transparency, security, clinical responsibility) and incorporate them into method selection as well as into evaluation and reporting standards. Students are able to communicate results in a target-audience-appropriate manner (e.g., to clinical partners, data stewards, research teams), clearly state assumptions and limitations, and justify decisions based on evidence. Furthermore, they strengthen their skills in academic work (critical literature research, reproducibility, clean documentation), teamwork, and structured

project management — especially for complex, multimodal, and data-sensitive tasks in healthcare.

Content: The module consists of two parts. Part 1 teaches the methodological foundations of modern deep learning and representation learning methods for medical data, thereby preparing for the specialized application areas in Part 2.

Part 1:

- Typical medical ML problems and data formats (Outcome-Prediction, Risk Stratification, Time-to-Event, clinical time series, tabular routine data)
- Deep Learning Architectures for biomedical data (e.g., CNNs, Transformers and Graph Neural Networks for imaging, time series and structured clinical data)
- Representation Learning and Self-supervised Learning: Feature Learning from large, heterogeneous medical datasets
- Multimodal Learning: Integration of clinical routine data, imaging, sensor data and omics data
- Uncertainty Quantification and probabilistic Deep Learning models
- Robustness, Generalization and Domain Shift in medical ML
- Model Interpretability and Explainable AI (XAI) in the clinical context
- Training Strategies for limited and noisy medical data (Data Augmentation, Transfer Learning, Weak Supervision)
- Evaluation of medical ML models: appropriate metrics, validation strategies, clinically relevant error types, Data Leakage and Bias
- Introduction to reproducible ML pipelines for health data (e.g., Experiment Tracking, Model Versioning, Reporting Standards)

Part 2:

- Reinforcement Learning in Medicine
- Decision Trees and Random Forests in Medicine
- Bayesian Inference in Machine Learning
- Quantum Machine Learning
- Clinical Foundation Models
- Causal Inference and Digital Twins
- Federated Learning as Privacy-Preserving ML
- Synthesis of medical data
- Knowledge Graphs and their Embeddings
- Prediction of Molecular Properties
- Prediction of Protein Properties
- Genomic Foundation Models and DNA Sequencing

Expected prerequisites:

The module *Introduction to Medical Data Science and Analytics*.

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 VU Advanced Machine Learning in Healthcare: Part 1 (TUW)

3,0/2,0 VU Advanced Machine Learning in Healthcare: Part 2 (MUW)

Advanced Software Engineering in the Biomedical Context

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- understand which software functions in a biomedical process turn the software into a medical device and thus require specific risk analyses,
- perform risk analyses according to applicable standards and guidelines to derive risk class, risks, and their mitigation, from which requirements such as functional limitations, quality assurance, or instructions for user roles result,
- design and validate acceptance scenarios to evaluate function, quality, and performance of a process or system in the biomedical context (e.g., through process simulation),
- design and validate a solution architecture for a process in the biomedical context,
- design and validate a concept for quality assurance of data and data-driven functions (e.g., data analysis or AI) in the biomedical context,
- estimate and quantify properties of software systems and projects in the biomedical context,
- apply typical development processes for software systems in the biomedical context,
- understand and implement architectures of software systems in the biomedical context,
- apply approaches for developing software for mobile devices,
- evaluate and select tools and frameworks for specific problem areas in the biomedical context,
- understand and apply tools and frameworks for software systems.

Non-technical competencies: In addition, students can identify, formulate, and discuss questions related to ethics, gender, and diversity in the context of the module content. Weiters können die Studierenden Fragestellungen von Gender, Ethik und Diversität im Kontext der Inhalte des Moduls identifizieren, formulieren und diskutieren.

Content:

- Insight into legal frameworks such as the EU Medical Device Regulation and its impact on the software development process, including CE certification

- Methods of risk analysis and classification of medical devices
- Differences between EU and USA
- Overview of characteristics of advanced software systems in the biomedical context (including value-based software engineering such as WinWin agreement negotiation, system size and complexity, system reliability/Quality of Service, extended software lifecycle, model-based software and systems engineering).
- Software Engineering approaches for advanced software systems in the biomedical context (including architectural styles such as component-based software engineering, lifecycle management and documentation, design patterns).
- Component-based development of complex software systems.
- Automation in the development of advanced software systems (including source code management, executable specifications such as Gherkin/Cucumber, Continuous Integration and Testing, advanced Build Management, persistence techniques such as Object Relational Mapping, data-driven approaches for software engineering and documentation, e.g., with AI services).
- Aspects of Enterprise Architectures in the biomedical context.
- The concept of Verification & Validation (V&V) and its application in software testing
- The properties of good software testing
- Overview of selected research and industry topics in the biomedical context (software engineering for mobile devices, software-intensive systems, ecosystems for software engineering tools and frameworks).

Expected prerequisites: Programming experience and at least one module in the field of Software Engineering.

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 VU Advanced Software Engineering in the Biomedical Context (MUW)
 3,0/2,0 PR Advanced Software Engineering in the Biomedical Context (TUW)

Advanced Topics In Medical Informatics

Workload for the module: min. 3,0 ECTS

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

Technical competencies: After successful completion of the module, students stay up-to-date with the rapidly advancing developments in medical informatics, such as Artificial Intelligence as well as other areas like 3D printing, robotics, quantum computing, etc., and learn about current innovations.

Non-technical competencies: Interdisciplinary skills for assessing new technologies and trends.

Content: Determined anew each academic year based on proposals. The respective content is made clear through subtitles in the offered courses.

Expected prerequisites:

These prerequisites are taught in the modules *Introduction to Digital Health*, *Introduction to Medical Data Science and Analytics*, and *Advanced Software Engineering in the Biomedical Context*.

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 semester.

AI Ethics

Workload for the module: 6,0 ECTS

Learning Outcomes: This module deals with the various ethical challenges and topics arising in the context of AI. Besides an in-depth introduction to ethical frameworks and AI ethics themes, the module focuses on the development of critical reflection and argumentation/discussion skills.

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

- explain and summarize central concepts and problems in AI ethics (e.g., AI alignment, algorithmic bias);
- describe fundamental ethical theories (e.g., utilitarianism, care ethics) and illustrate their application to AI ethics topics through examples;
- analyze and construct a critical ethical reflection on central technical and philosophical challenges in AI ethics (e.g., fairness, sustainability, AI alignment);
- formulate and defend clearly structured, state of the art informed arguments on key AI ethics questions (e.g., the right to explanation, data privacy), engaging with counterarguments; and
- justify the importance of ethical reflection in AI development, using ethical reflection and/or case studies to support claims.

Non-technical competencies: Students will acquire critical thinking skills that are strongly rooted in humanity studies. They will also learn how to study text on policy, law, and regulations concerning AI.

This course will address ethics, gender, and diversity in the following ways: The main purpose of the course is for students to develop critical reflection skills on ethical aspects of AI, this includes obtaining a broad and diverse overview of various perspectives on

ethical challenges. It reflects explicitly on questions of gender and diversity in terms of fairness and bias both in ethics and in AI. Furthermore, the literature for the course is aimed at reflecting diverse backgrounds too.

Content:

- Novel ethical challenges in AI such as disinformation, explainability, sustainability, data-privacy, autonomy;
- methods such as embedded ethics, multi-scale ethics, AI ethics audits, AI alignment, human-in-the-loop AI;
- ethical theories including consequentialism, utilitarianism, virtue ethics, deontology, care ethics, and critical methods such as feminist ethics.

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 AI Ethics

Artifact-based Design

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- apply iterative design methodologies, including prototyping, testing, and refinement, to create tangible and digital artifacts
- understand the concepts of ubiquitous computing describing the deployment and integration of computing technology into everyday objects and environments
- understand and apply the relevant concepts and fundamental technologies (e.g., context-awareness, localization and sensing technologies, machine learning on the edge, microprocessor programming, and design of ubiquitous computing applications)
- understand the specific topics of activity recognition, privacy concerns and preserving approaches, business applications, and related business models
- apply your theoretical knowledge from the class to develop a specific ubiquitous computing project
- investigate working principles of sensors and their application for context detection

Non-technical competencies:

- analyze user needs and societal challenges to identify design opportunities
- evaluate the effectiveness of design solutions through testing and iteration

- synthesize theoretical frameworks with hands-on design practices to develop impactful artifacts
- demonstrate critical thinking in balancing user requirements, technical feasibility, and societal impact
- collaborate effectively in interdisciplinary teams to address complex design problems
- reflect on the societal implications of their design work and make informed, ethical decisions
- communicate design concepts and processes clearly and persuasively to diverse audiences
- adapt to feedback and iterative processes with resilience and a growth mindset

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. Students will cultivate the ability to design and implement both tangible and digital artifacts that are informed by user needs and broader societal contexts. Through analyzing user requirements and societal challenges, they will identify meaningful design opportunities and demonstrate critical thinking by balancing user expectations, technical feasibility, and potential societal impact. Ethical reflection will play a key role, as students consider the broader implications of their work, including privacy-related concerns, and make responsible design choices. Additionally, they will learn to communicate their design concepts and processes clearly and persuasively to a variety of audiences.

Content:

- introduction to artifact-based computing, the history of computing disappearing into the background and serving the user's needs proactively; critical review of the vision of ubiquitous computing in the context of today's developments.
- notion of context-aware computing, the principle of integrating implicit input from the user and environment for providing more meaningful services to the user.
- investigation of working principles of sensors and their application for context detection.
- review of location technologies, discussion of privacy-preserving approaches.
- data models and standards for resource-constrained devices.
- revisiting design, prototyping, and evaluation methods.
- review of Internet of Things business models.
- discussion of privacy-related implications.
- state of the art of (physical) fabrication technologies.
- outlook on emerging technologies.

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 Artifact-based Design

Assistive Technologies

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- apply the necessary knowledge of anatomy and physiology to understand disabilities and technical solutions, as well as knowledge of the causes and effects of physical disabilities and age-related functional limitations.
- understand models of disabilities, basic rehabilitation technology and gerontechnology
- communicate with disabled people (alternative and augmentative communication)
- compare social and assistive robots
- describe aspects of HCI/HRI in the area of assistive systems, proxemics
- explain ambient/active assisted living (AAL) and smart environment technologies
- plan and to apply participatory user involvement, data protection and ethics
- give examples for relevant support tools for disabled and elderly people
- refer to guidelines for barrier-free web content and web sites
- use partially automated tools for checking websites and web content

Non-technical competencies:

- select suitable methods for abstraction, solution finding and evaluation
- apply interdisciplinary and system-oriented approaches and flexible ways of thinking
- handle technologies, software tools and standards
- precisely write documentation of solutions
- provide convincing technical presentations and communication in an interdisciplinary environment
- raise awareness of the challenges faced by people with disabilities and older people, as well as the importance of accessible design for technical products.
- understand challenges arising from disability and age
- interact and cooperate with disabled and elderly people
- assess impact and evaluate ethics
- increase individual creativity and innovation potential
- communicate and accept criticism
- reflect their own abilities and limitations

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, among other things, aspects such as access to assistive technology as a right, issues of distributive justice and gender equality in the provision of assistive technology, consideration of diversity beyond disability, and the demand for appropriate diversity in design teams.

Content:

- terms, classifications and definitions of disability and aging

- medical basics, primarily physiology of the sensory organs and their damage
- demographic aspects of disability and aging
- theoretical basics and methodology of assistive technologies
- special aspects of HCI for disabled and elderly people
- design and use of technical aids (e.g. orientation aids and everyday aids for blind and visually impaired people, special aids and techniques for deaf-blind people, electronic systems for people with mobility and movement disabilities), case studies and social/economic aspects
- basics of communication technology and special features of alternative and augmentative communication (vocal, auditory, motor and visual communication disabilities)
- systematics of communication aids and methods of alternative and augmentative communication (tactile representations, speech synthesis, image and symbol languages, visual and tactile languages)
- assistive technologies in the use of media and mass media
- introduction to the functional principles of socially assistive robots (SAR), assisted living and smart environments and sensor based systems
- examples of current developments and trends in SAR and AAL
- introduction to special interaction aspects of autonomous assistive systems, multi-modal communication with autonomous systems
- introduction to guidelines for creating accessible web pages and web content
- introduction to using semi-automated tools to check websites and web content

Expected prerequisites:

- basic knowledge of anatomy and physiology
- basic knowledge of HTML and CSS

These prerequisites are taught in the modules *Access Computing* of the *Informatics* bachelor program.

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 Assistive Technologies

Bioinformatics

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to analyze -omics data using the most modern algorithms and place them in a biological context. In particular, students can:

- explain the experimental conditions of the most important -omics technologies and place them in a cell biological context.
- explain and apply the basic algorithms.
- describe the functionality of central workflows.
- implement workflows using given datasets.
- place results in a biological context and evaluate them.

Non-technical competencies: Students develop a deep understanding of the biological complexity underlying technical applications (Microarrays, RNASeq, Proteomics). They learn to place scientific findings in the context of medical informatics and recognize the relevance of biological data for clinical decisions.

Content:

- What does the wet-lab equipment for generating -omics data look like and how does it work (Microarrays, RNA Sequencers, Mass spectrometers)?
- What algorithms are there for estimating differentially expressed genes/proteins (Linear models, statistical tests) and how are they implemented in R
- What algorithms are there for determining the biological context (TEA, GSEA, GSVA)?
- What algorithms are there for determining regulatory networks (WGCNA, SEM)?
- Overview of Machine Learning Methods in -Omics data Analysis.

Expected prerequisites: None. Basic knowledge of Python/R is advantageous.

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 Bioinformatics (MUW)

Biological Basis of Disease

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to describe the structure and function of the human body in healthy and diseased states. In particular, students can:

- explain the anatomical structure of the human body, including the skeletal system and spatial relationships.
- explain cell biological processes and general tissue science (epithelia, connective, bone, muscle, and nerve tissue).

- name the fundamental histological characteristics of tissues and their pathological changes (morphology and pathomorphology).
- describe the functioning of central organ systems (cardiovascular, respiratory, digestive, urogenital system, and vital functions).
- understand physiological mechanisms of the nervous system such as action potentials, synaptic transmission, and reflexes.
- define pathological basic concepts such as cell damage, inflammatory processes, tissue replacement, and the development of neoplasms (tumors).
- know and evaluate the essential molecular foundations of pathological changes.

Non-technical competencies: Students develop a deep understanding of the biological complexity underlying technical medical applications (such as EEG, fMRI, or EMG). They learn to place scientific findings in the context of medical informatics and recognize the relevance of biological data for clinical decisions.

Content:

- **Anatomy:** Structure of the body, skeleton, cardiovascular system, respiration, digestive tract, urogenital system, and sensory organs.
- **Histology & Cell Biology:** Microscopic techniques, tissue science (cartilage, bone, muscles), cell organelles, molecular biology, and genetic encoding.
- **Physiology:** Membrane potentials, muscle function, respiratory and cardiac physiology, blood, hormone system, and central nervous system. Application of physiology through practical insights into EMG, NLG, and electrical stimulation.
- **Pathology:** Cell damage, inflammation science, oncology (neoplasms), immunopathology, as well as molecular and computational pathology.

Expected prerequisites: No specific medical prerequisites required; basic interest in biological and scientific questions.

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 VU Biological Basis of Disease, Part I: Anatomy and Histology (MUW)

3,0/2,0 VU Biological Basis of Disease, Part II: Physiology and Pathology (MUW)

Computational Neuroscience

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- enumerate neuroimaging techniques as well as their limitations and age-specific requirements.
- identify, explain, and contrast the most important theories, principles, concepts, and algorithms of Computational Neuroscience.
- understand the current scientific literature (state of the art) in the field of Computational Neuroscience.
- critically evaluate suitable preprocessing pipelines for the analysis of brain activity in perinatal, infant, toddler, and adult cohorts.
- select appropriate processing techniques for neuroimage analysis, including registration, segmentation, prediction, representation learning, and atlas learning.

Non-technical competencies: In addition, students are able to identify, formulate, and discuss questions related to ethics, age, technological domain dependence, and diversity in the context of the module content. In particular, this includes how algorithms developed for adult cohorts may fail in the perinatal setting, or how approaches need to be trained to generalize to healthy and pathological cases. For example, the ongoing myelination process in the developing brain leads to a contrast flip between pre- and postnatal periods. As a result, intensities and contrasts in MRI imaging change. Students develop competencies to address these challenges, for example through the selection of suitable scanning and processing techniques, age-adapted atlases, and machine learning training routines.

Content:

- Structure of age-specific neuroimaging data formats/modalities and acquisition strategies.
- AI-based analysis techniques for brain shape and volume analysis (segmentation, registration, surface extraction).
- Pipelines for analyzing structural connectivity, including various tractography techniques, graph-based network analysis, and non-Euclidean representation learning with Machine Learning (Graph Convolutional Neural Networks).
- Task-based methods for analyzing functional connectivity, including paradigm design, multivariate analysis pipelines for adults, available toolboxes, as well as feature importance and visualization techniques.
- Resting-State-based methods for analyzing functional connectivity, including preprocessing pipelines and filtering, graph-based network analysis, parcellation schemes, and visualization techniques.
- Analysis concepts for the developing fetal, infant, and toddler brain.
- Analysis of fetal and neonatal brain development.
- Atlas learning and registration techniques.
- Pre-/post-surgical assessment, reorganization, and analysis of the pathological brain.
- Postmortem and histopathological, ML-based evaluation methods in neuroscience.
- Large Language Models and Deep Learning Agents in Computational Neuroscience.

Expected prerequisites: Basic knowledge of Machine Learning, image processing, and programming.

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 Computational Neuroscience (MUW)

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

Data Stewardship

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of this module, students will be able to:

- explain research data lifecycle
- create a Data Management Plan
- apply FAIR principles in practice
- differentiate between different license types
- explain what persistent identifiers are
- review existing data management practices
- represent information using machine-actionable DMP
- discuss differences between repository systems
- explain how findability and interoperability of data can be achieved
- describe components of an Research Data Management infrastructure
- describe the scope of RDM policies and how they drive DM activities and obligations
- describe ways to certify a repository and to evaluate certification criteria
- implement reproducible experiments
- explain challenges in digital preservation
- identify significant properties of digital objects and create preservation plans
- explain the role of the OAIS and apply it correctly when developing digital archives
- explain the concepts and processes in trusted research environments for interacting with sensitive or confidential data.

Non-technical competencies: After successfully completing the module, students will be able to understand the importance of the role of data, specifically sensitive data (gender, ethnicity, medical data, personal attitudes, etc.) and be aware of processes for determining the ethically correct handling of data in collection and analysis.

Content:

- Reproducible Research

- Machine-actionable Data Management Plans
- Research Data Management Services,
- Data Identification and Citation
- Digital Preservation Challenges, Preservation Actions
- ISO OAIS Standard
- Preservation Planning
- Repository Systems
- Repository Certification
- Trusted research environments
- FAIR principles, FAIR metrics

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 VO Data Stewardship

3,0/2,0 UE Data Stewardship

Generative AI, General AI

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: This module provides students with a holistic understanding of universally applicable AI: technical foundations, practical use, alignment challenges, and systemic impacts. Students learn to effectively use AI agents while maintaining critical judgment about capabilities and limitations. After successful completion of the module, students are able to:

- explain the central developments that have led from specialized ("narrow") AI systems to universally applicable Foundation Models, and justify why generality represents a qualitative leap in AI capabilities
- describe at a conceptual level how Large Language Models work, including pre-training, fine-tuning, and alignment techniques such as RLHF
- critically evaluate outputs from AI systems and recognize typical error modes such as hallucinations, sycophancy (excessive agreement), and overconfident errors
- effectively deploy AI agents for complex tasks, including appropriate prompting, supervision, and verification practices;
- explain central concepts of AI alignment, including why aligning AI systems with human intentions is technically challenging;
- analyze how AI capabilities interact with larger systems in science, economy, and society;

- assess opportunities and risks of AI applications in the biomedical context – considering technical capabilities and domain-specific requirements;
- argue about short-term AI developments and their implications for research and professional practice.

Non-technical competencies: Students develop skills for critical thinking when evaluating rapidly evolving technologies. They learn to appropriately calibrate trust and distinguish between reliable and unreliable AI outputs. Additionally, they develop strategic thinking about how to position themselves professionally in an environment of accelerating AI capabilities. The module addresses ethics, gender, and diversity at multiple levels. The systemic perspective includes questions of power concentration, access to AI capabilities, and the values that shape AI development.

Content:

- Topic 1: From specialized AI to general AI
- Topic 2: How Foundation Models work
- Topic 3: Evaluating AI systems and trusting them appropriately
- Topic 4: AI agents and autonomous systems
- Topic 5: Practical skills for working with AI agents
- Topic 6: A journey through biomedical use cases
- Topic 7: AI-Alignment
- Topic 8: The larger system
- Topic 9: Looking into the future

Expected prerequisites: Basic understanding of Machine Learning concepts (module "Introduction to Biomedical Data Science and Analytics"), familiarity with the basics of biomedical informatics (module "Introduction to Digital Health")

Applied teaching and learning methods and appropriate performance assessment: xx

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 Generative AI, General AI (MUW)

Human-Centered AI

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- explain user interface basics and AI system design principles;

- describe fundamentals of supervised, unsupervised, and reinforcement learning;
- explain and apply gesture recognition (sequence classification, Markov property, gesture and pose detection from video);
- implement adaptive user interfaces (automated optimization based on human factor parameters); and
- work with tools and frameworks (TensorFlow, Unity ML-Agents).

Non-technical competencies: After successful completion of the module, students are able to:

- analyze parameter estimation and model selection to suit specific scenarios;
- evaluate human-AI interaction from a human-centered perspective;
- demonstrate critical thinking in balancing user requirements, technical feasibility, and societal impact;
- collaborate effectively in interdisciplinary teams to address complex design problems;
- design AI systems that effectively support or cooperate with human users;
- communicate design concepts and processes clearly and persuasively to diverse audiences; and
- adapt to feedback and iterative processes with resilience and a growth mindset.

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. Ethics, gender, and diversity are core topics of the Human-Centered AI module. Students critically examine how AI systems can reinforce or mitigate social inequalities, with focused discussions on algorithmic bias, fairness, and inclusive design. The module emphasizes the importance of considering diverse user perspectives. Through case studies, ethical frameworks, and participatory design methods, students learn to build AI systems that are not only effective, but also equitable and socially responsible.

Content:

- Basics of AI systems: supervised, unsupervised, and reinforcement learning.
- Recommender systems: definitions, collaborative filtering, similarity measures.
- Natural language processing: syntax, semantics, tokenization, normalization, stemming, chatbot interaction.
- Gesture recognition: sequence classification, Markov property, gesture and pose recognition from video.
- Adaptive user interfaces: automated optimization based on human factor parameters.
- Explainable AI: local and global interpretability, LIME, SHAP, automated rationale generation.

Expected prerequisites:

- Probability Theory

These prerequisites are taught in the module *Statistik und Wahrscheinlichkeitstheorie* of the *Informatics* bachelor program.

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 Human-Centered AI

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 Medical Data Science and Analytics

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- explain fundamental concepts of medical Data Science and Machine Learning, including data types, scale levels, distributions, classification, regression, and clustering.
- analyze, prepare, and preprocess medical datasets, including handling missing data, standardization, and integration of heterogeneous data sources.
- apply statistical models such as linear and logistic regression, Mixed-Effects Models, and survival analyses (Kaplan-Meier, Cox-Regression) and interpret their results.
- select, train, and evaluate basic ML methods (e.g., Decision Trees, Random Forests, Support Vector Machines, neural networks) using cross-validation and regularization.
- critically assess model complexity, overfitting, regularization, and feature selection (e.g., Lasso, Ridge).

- compare statistical and ML-based approaches and understand their assumptions, strengths, and limitations in the context of medical applications.
- identify typical challenges of medical data analysis — such as small sample sizes, high dimensionality, and uncertainty — and derive appropriate methodological strategies.

Non-technical competencies: Students develop a critical understanding of the application of data-driven methods in medicine and reflect on their limitations and ethical implications. They are able to identify and discuss questions related to data quality, bias, reproducibility, and generalizability. In addition, they strengthen their skills in interdisciplinary collaboration between medicine, statistics, and informatics, as well as in the clear communication of analytical results to expert and non-expert audiences.

Content: The module consists of two parts:

Part 1 — Statistical Basics of Medical Data Science:

- Introduction: aims and scope of Biostatistics (including statistical software)
- Planning a study for medical science (including types of studies; observational studies; missing data mechanisms; study protocol; initial data analysis; reporting guidelines)
- Analysis of variance (including multiple testing problem; analysis of covariance; repeated measures)
- Modelling continuous outcomes (including general aspects of model purpose and multivariable model building; model diagnostics; clustered observations)
- Modelling binary outcomes (including maximum likelihood principle; logistic regression; performance measures)
- Describing and modelling time-to-event data (including Kaplan-Meier estimator; Cox proportional-hazards regression model; explained variation)

Part 2 — Foundations of Medical Machine Learning:

- Types of medical data from the perspective of machine learning
- Data preparation: cleaning, integration, preprocessing, and standardization
- Fundamental learning tasks: classification and regression
- Supervised and unsupervised learning
- Linear vs. non-linear models, learning representations from data
- Classical methods: Support Vector Machine, Ensemble Methods, Bootstrapping, Boosting
- Modern Deep Learning architectures: Convolutional Neural Network, Transformer
- Generalization, overfitting, regularization, inductive assumptions (inductive bias), No-Free-Lunch Theorem
- Limitations of machine learning

Expected prerequisites: Mathematische Grundkenntnisse (Analysis, Vektoralgebra) und Grundkenntnisse der Statistik (deskriptive Statistik, schließende Statistik und ihre wesentlichen Tests).

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 VU Statistical Basis of Medical Data Science (MUW)

3,0/2,0 VU Foundations of Medical Machine Learning (TUW)

Introduction to Digital Health

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- correctly classify and contextualize fundamental concepts of medical documentation
- describe health information systems based on elementary properties, such as the type and standardization of their content, institution- vs. patient-centeredness, direct vs. indirect documentation
- distinguish medical classifications and nomenclatures and describe important representatives of both types of ordering systems
- characterize common types of medical documentation, such as electronic health and patient records, registries, clinical studies
- provide an overview of important eHealth implementations in European and Austrian healthcare
- describe characteristics of open distributed information systems
- distinguish between common types of communication and data exchange in healthcare and understand their interrelationships
- distinguish the different levels of interoperability in health data exchange and name prerequisites for semantically interoperable health data exchange
- understand the central concepts, methods, and design principles of Human-Computer Interaction in the clinical and Wellbeing context and apply them to questions of usability, user experience, accessibility, and accessibility, including telemedicine usage scenarios.
- critically analyze technological innovations such as Wearables, medical sensors, and robotics with regard to usage contexts, interaction forms, and impacts on health and wellbeing, including their potential for digital biomarkers.
- evaluate data-based digital support and intervention systems in the context of diagnosis, monitoring, prevention, and therapy from a user-centered perspective, with particular consideration of patient-centered outcomes.
- design and reflect on digital care scenarios considering heterogeneous user groups, organizational frameworks, and situational usage contexts.

- classify and critically discuss current research trends, innovation processes, and early evaluation approaches in digital health and wellbeing research.
- understand legal, ethical, and societal frameworks of digital health and wellbeing technologies and integrate them into design and evaluation processes.

Non-technical competencies: Through additional lectures by clinicians, students get a first-hand impression of the significance of eHealth technologies in healthcare for healthcare service providers. The exchange with medical experts offers a first introduction to developing corresponding communication skills for medical informatics professionals in their future role as a mediation interface between technology and medicine.

Content: The module consists of two parts:

Part 1 — Digital Health Foundations and Data Governance:

- Fundamentals of Documentation: Central terms, definitions, and types of medical documentation.
- Order Systems and Semantics: Introduction to medical classifications (ICD, OPS) and nomenclatures (SNOMED CT, LOINC). Fundamentals of semantic interoperability.
- System Architectures: Characteristics of health information systems (HIS, PIS) and open distributed information systems.
- Data Exchange and Interoperability: Types of exchange of health data (HL7 FHIR, IHE Profiles).
- Public Health Framework: eHealth milestones in Europe and Austria (ELGA, e-prescription).
- Telemedicine in Practice: Telecommunication, Tele-Cardiology (as a case example)

Part 2 — Human-Computer Interaction for Health and Wellbeing

- Introduction to Human-Computer Interaction (HCI): Design principles, usability, user experience, accessibility, and availability in clinical daily life as well as in applications for wellbeing.
- Technological Innovations: Wearables, medical sensors, and robotics in healthcare and wellbeing context.
- Digital Therapeutics and Data-based Support: Integration of usage and health data in diagnosis, monitoring, prevention, and supportive intervention processes.
- Telemedicine and Digital Care Concepts: Design and use of distributed care scenarios considering different user groups and usage contexts.
- Research and Future Perspectives: Current research trends, user-centered innovation processes, early evaluation, and participatory design approaches.
- Legal and Ethical Frameworks: Data protection, regulation, inclusion, and responsible design of digital health and wellbeing systems.

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 VU Digital Health Foundations and Data Governance (MUW)

3,0/2,0 VU Human-Computer Interaction for Health and Wellbeing (TUW)

Introduction to Molecular Biology

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the first part of the module, students are able to describe and understand the fundamentals of enzymatically catalyzed chemical reactions that underlie cellular metabolism. This enables them to analyze this complex network with regard to a single cell or entire organs using bioinformatics methods. These analyses, which fall under the terms "Proteomics" and "Metabolomics", represent important tools for describing pathological changes in metabolism in medicine and for applying or developing appropriate therapies based on the results. After successful completion of the second part of the module, students are able to describe and understand the fundamentals of the structure and functioning of the human genome. In addition, the basis is created to understand the complex signal networks between cells and their molecular basis. This enables students to analyze pathological changes in the genome and resulting changes in the proteome and signalosome using bioinformatics methods. These bioinformatics analyses represent an important tool for describing pathological changes in cell division regulation in medicine, which often lead to cancer, and for applying or developing appropriate therapies based on the results.

Non-technical competencies: In addition, students acquire competencies to responsibly and interdisciplinarily classify molecular biological content in the biomedical context. They can communicate central concepts and results (e.g., on genome changes, signal transduction, proteome/metabolome) in a target-audience-appropriate manner and critically reflect on the uncertainties, limitations, and interpretive scope that arise from data quality, measurement methods, and model assumptions.

Content: The module consists of two parts:

Part 1:

- Fundamentals of general chemistry and thermodynamics as far as necessary for understanding chemical bonds and chemical reaction equilibria.
- Structure and composition of proteins. Methods for purification of proteins and analysis and representation of their molecular structures.
- Function of enzymes and description of enzymatically catalyzed reactions.
- Description of cellular metabolism using the example of catabolic energy metabolism and the formation of ATP.

Part 2:

- Structure and function of DNA and RNA.
- Cell division and DNA replication.
- Organization of the genome and sequencing of genomes.
- Mutations and DNA repair in connection with cancer development.
- Gene expression and protein biosynthesis.
- Fundamentals of signal transduction.

Expected prerequisites: None. Part 1 provides the prerequisites for Part 2.

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 VO Introduction to Molecular Biology, part 1 (MUW)

3,0/2,0 VO Introduction to Molecular Biology, part 2 (MUW)

Introduction to Neuroscience

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: The lecture provides a broad introduction to neuroscience. After successful completion of the module, students are able to

- explain fundamental concepts of neurochemistry and central transmitter systems and apply them to simple examples.
- describe central principles of neurobiology (important cell types, selected cell functions) as well as fundamentals of human genetics in the neuroscience context.
- name essential structures of micro- and macroscopic neuroanatomy and classify them functionally.
- explain core elements of neurophysiology (action potential, synapses) as well as nerve pathways, circuits, and networks, and discuss selected systems (including autonomous nervous system, stress axis, sensory and motor functions).
- explain selected aspects of pathophysiology of the nervous system using neuropsychiatric examples and classify basic diagnostic criteria (including genetic diseases).
- describe basic concepts of therapy, care, and intervention (e.g., pharmacotherapy, neurostimulation) and outline their objectives/limitations.
- summarize selected special topics (e.g., sleep, pain, memory, limbic system) and link them with the basic concepts of the module.

Non-technical competencies: In addition, students acquire interdisciplinary competencies to responsibly classify neuroscience content. They can communicate central concepts and

findings from different levels (molecular, cellular, systemic, clinical) in a target-audience-appropriate manner and critically reflect on the uncertainties and limitations arising from measurement methods, study designs, and data quality. Furthermore, they strengthen scientific work techniques such as structured literature research, critical source evaluation, as well as traceable documentation and presentation of results — also in the context of a seminar paper. Another focus is on the reflection of ethical and societal aspects of neuroscience.

Content:

- Fundamental concepts of neurochemistry and transmitter systems
- Fundamental concepts of neurobiology: cell types and selected functions of specific cells; basic understanding of human genetics
- Fundamental concepts of micro- and macroscopic neuroanatomy
- Fundamental concepts of neurophysiology: action potential and electrochemical synapses, nerve pathways, circuits, networks; selected systems including components of the autonomic nervous system, the stress axis, as well as selected sensory and motor functions
- Pathophysiology of the nervous system – selected examples of neuropsychiatric diseases and diagnostic criteria, including genetic diseases
- Selected aspects of therapy, care, and intervention, including pharmacotherapy and neurostimulation
- Several special topics (may vary depending on cohort), e.g., sleep, pain, sexual dimorphisms in the nervous system, memory, function of the limbic system

Expected prerequisites: Basic knowledge of cell biology is helpful but not mandatory.

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:

4,0/2,5 VO Introduction to Neuroscience (MUW)

2,0/1,5 SE Introduction to Neuroscience (MUW)

Logic-based Artificial Intelligence

Workload for the module: 6,0 ECTS

Learning Outcomes: At the end of this module, the students will be familiar with a range of logic-based formalisms for describing problem domains. They will be able to select an adequate formalism for a problem of interest, and correctly model the problem in the selected formalisms. The student should also be able to select an adequate reasoning engine for solving the problem at hand, informed by an understanding of the problems it implements.

Technical competencies: The students who complete the module are able to

- read and write correctly domain specifications in classical predicate logic,
- decide whether a given statement is consistent with or entailed by a logic specification,
- describe a given domain using a description logics of adequate expressiveness,
- understand and solve instances of classical DL reasoning services: consistency, instance checking, and concept subsumption,
- understand the principles of nonmonotonic reasoning and recognise different non-monotonic entailment relations,
- correctly write logic programs with default negation and compute their answer set semantics,
- model probabilistic domains and draw inferences from them,
- recognise different types of decision rules, and
- apply algorithms to learn rules from tabular data.

Non-technical competencies: Students are able to model problem domains accurately, and to assess and criticize the adequacy of different techniques for specific situations. The students can identify and verbalise ethical challenges that arise when applying AI techniques in the real world.

The material taught in this module does not involve gender aspects. Teaching resources and methods will be developed with an awareness of diversity and ensuring a welcoming environment for students from underrepresented groups.

Content: The module discusses the following topics:

- propositional and predicate logic as knowledge representation languages;
- description logics and ontological reasoning;
- tractable ontological reasoning;
- foundations of nonmonotonic reasoning;
- answer-set programming and declarative problem solving;
- logics with uncertainty;
- rule learning; and
- applications.

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 Logic-based Artificial Intelligence

Medical Signal Processing and Imaging

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- understand the nature of digitized biosignals and the information contained therein and apply suitable processing algorithms for transformation, representation, and further processing.
- identify data from imaging of different medical devices, explain their generation process and reconstruct it, as well as understand typical dangers/risks.
- understand the current technical literature (state of the art) in the field of medical signal processing and imaging.
- apply suitable processing techniques to extract clinically relevant information from these signals and images.

Non-technical competencies: In addition, students are able to identify, formulate, and discuss questions related to ethics, gender, and diversity in the context of biomedical signal and image processing. In particular, this includes how algorithms can reflect or amplify societal biases. Students develop competencies to address these challenges, among others through statistical analysis of their datasets and debiasing techniques, to avoid performance degradation for marginalized groups.

Content: The module consists of two parts:

Part 1 — Acquisition of Biosignals and Imaging Methods in Medicine (physical fundamentals, measured quantities, derivation/recording techniques, signal and image reconstruction, information encoding, clinical benefit, and application):

- Electrocardiography
- Electroencephalography
- Optical imaging
- X-ray techniques/projection radiography
- (X-ray) Computed Tomography
- Magnetic Resonance Tomography
- Ultrasound/Ultrasonography
- Optical Coherence Tomography
- Photoplethysmography

Part 2 — Analysis of Biosignals and Medical Image Data:

- Digitization of signals/image data (sampling theorem, quantization)
- Function spaces for signal/image representation (Fourier series, wavelets, ...)
- Signals and images as stochastic quantities
- Methods of digital filtering (signal/image enhancement)
- Techniques for signal and image restoration in medical applications
- Segmentation methods for medical signal/image data (Graphcut)
- Common feature spaces in medical signal/image analysis
- Classifiers for feature spaces in medicine
- Harmonization techniques for medical images
- Methods of signal and image analysis in the age of machine learning (Convolutional Neural Networks, ...)

- All mentioned methods are presented with application reference to medical signal/image data (EEG, ECG, CT, MRI, ultrasound, OCT, ...)

Expected prerequisites: Mathematische Grundkenntnisse (komplexe Zahlen, Analysis, etc.)

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 VU Biosignal Processing (MUW)

3,0/2,0 VU Medical Imaging and Image Processing (MUW)

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

Methodological Foundations of Public Health Informatics

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- explain the fundamentals and central concepts of Outcomes Research and translate them into measurable variables for digital reporting and decision support.
- select, define, and justify suitable outcome domains, indicators, and measures for concrete clinical or health system questions.
- design dashboards as socio-technical interventions: specify users, decisions, workflows, context, and intended actions and link metrics with decision points.
- create structured dashboard specifications.
- develop and prototype outcomes dashboards, applying principles of Visual Analytics, information hierarchy, and usability — with a focus on interpretability and clinical relevance.
- perform basic data preparation and validation and critically examine the validity of metrics.

- evaluate the quality and utility of dashboards and select appropriate methods.
- explain the fundamentals of epidemiology and correctly calculate and interpret central measures.
- select, apply, and appropriately interpret advanced epidemiological methods, especially regression models, for simple questions.
- independently perform simple calculation and analysis examples — optionally using common software (e.g., SPSS, R, MS Excel) — and document results comprehensibly.

Non-technical competencies: In addition, students acquire competencies for interdisciplinary work in the Public Health and Health Informatics context. They can systematically assess requirements and information needs of different stakeholders (e.g., clinics, management, Public Health) and translate them into understandable specifications, communicate results in a target-audience-appropriate manner, and justify methodological decisions transparently. They develop data and method competencies in the sense of reproducibility (documentation, metric definitions, versioning) as well as a critical awareness of risks and side effects of data-driven decision support (misinterpretation, unintended incentive systems, algorithmic bias). Furthermore, they reflect on the responsible handling of sensitive health data (data protection, access controls, governance) and strengthen team and project competencies through the planning, implementation, and presentation of a practice-oriented portfolio project.

Content: The module consists of two parts:

Part 1 — Outcomes Research:

- Overview: Outcomes Research and Health Services Research — goals, questions, data types (routine data, registries, cohorts, surveys).
- Selection and operationalization of outcome measures (including PROMs/PREMs, quality/safety indicators) and translation into digital metrics.
- Dashboards as socio-technical interventions: Use Case Design, user roles, workflows, responsibilities, and governance.
- Dashboard Blueprint: Metric Dictionary, data provenance, refresh rates, thresholds, drill-down logic, documentation.
- Data preparation and validation: linking/aggregation, missingness, bias, reliability, stability, and sensitivity of indicators.
- Visual Analytics & User Centered Design: Visual Encoding, information hierarchy, interpretability, accessibility.
- Evaluation: Usability and comprehension tests, trust/actionability, Mixed Methods approaches, log data analysis.
- Ethics, fairness, security, and privacy in Outcomes Dashboards: Identify risks and derive appropriate mitigation measures.
- Project: End-to-End Portfolio (Question → Indicators → Prototype → Evaluation Plan → Deployment Recommendations).

Part 2 — Epidemiology:

- Fundamentals of epidemiology from medical and methodical-statistical perspectives.
- Important terms and measures (including standardized rates) — calculation, interpretation, and limitations.
- Fundamentals of study designs, bias, and confounding (classification and practical consequences).
- Advanced methods in epidemiology, especially regression models (introduction and application).
- Exercise: Calculating and interpreting using simple examples; optionally supported by software (SPSS, R, MS Excel, etc.).

Expected prerequisites: Basic knowledge of (Public) Health/medical informatics and a fundamental understanding of medical and Public Health concepts is helpful. Mathematical-statistical foundations are taken up in the module and consolidated through exercises.

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 VU Outcomes Research (MUW)

3,0/2,0 VU Epidemiology (MUW)

ML in Medical Imaging and Precision Medicine

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- identify, explain, and critically evaluate central concepts, models, and algorithms of Deep Learning for medical image analysis, including classification, localization, segmentation, representation learning, and generative modeling.
- understand and critically evaluate current scientific literature in Machine Learning (ML)/Deep Learning (DL), medical image processing, and precision medicine.
- design, implement, and evaluate end-to-end Deep Learning workflows for applications in medical imaging, including data analysis, preprocessing, model training, validation, and interpretation, using modern software frameworks (e.g., PyTorch).
- select and justify suitable ML/DL methods for medical imaging problems – based on data characteristics such as modality, class imbalance, annotation uncertainty, missing data, multicenter variability, and the objectives of the task.
- compare traditional ML-based approaches (e.g., PCA, statistical and Active-Shape models, SVMs, Random Forests) with modern Deep Learning methods and understand their assumptions, strengths, and limitations.

- apply advanced Deep Learning concepts such as Convolutional Neural Networks, transformer-based models, self-supervised and unsupervised learning, generative models, multimodal learning, and Foundation Models in the context of medical imaging.
- assess robustness, generalization capability, and uncertainty of medical AI systems, including aspects such as Domain Adaptation, Domain Generalization, Continual Learning, and Federated Learning in multicenter and longitudinal settings.

Non-technical competencies: In addition, students can identify, formulate, and discuss questions related to ethics and fairness in the context of the development and use of Deep Learning systems in medical image analysis and precision medicine. In particular, students understand how Deep Learning models can reflect, amplify, or mitigate biases, for example through:

- distorted or incomplete training datasets that lead to reduced performance for underrepresented patient groups.
- modality-, location-, or population-specific biases in medical (image) data.
- challenges due to missing data, class imbalance, and unequal access to diagnostic technologies.

Students develop strategies to address these challenges – for example through bias-aware data preparation, appropriate evaluation protocols, explainable AI (XAI) methods, and uncertainty estimation. Furthermore, they reflect on ethical and societal frameworks that determine the transfer of Machine Learning models into clinical research and medical routine practice.

Content:

- Model development workflow
- Fundamentals of Deep Learning & CNNs for classification
- Important DL architectures and concepts – Classification & Regression
- Important DL architectures and concepts – Localization & Segmentation
- Time series and Transformers
- Explainability, uncertainty
- Representation learning and generative models
- Handling multicenter data
- Multimodal DL and missing data
- Foundation Models and agent approaches
- Transfer to research and practice

Expected prerequisites: Basic knowledge of Machine Learning (fundamental Supervised Learning, traditional ML methods, fundamentals of neural networks including Backpropagation) from module Introduction to Biomedical Data Science and Analytics, solid programming skills (e.g., Python).

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 ML in Medical Imaging and Precision Medicine (MUW)

Modeling and Simulation for Medical Informatics

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to independently perform simple modeling and simulation experiments for a given research problem in the field of medical informatics.

With respect to the methodological content, this goal implies that students

- understand the principles of modeling and simulation and are able to describe the involved standard process.
- are able to distinguish and classify different modeling methods and are able to name their typical fields of application.
- are able to apply the modeling methods to model given real systems and, furthermore, develop and analyse conceptional models.
- are able to implement conceptional models in certain simulators and to perform simulations with them.

With respect to the application focus, students

- understand basic concepts of Health Technology Assessment (HTA) and Comparative Effectiveness Research (CER), and their role in evaluating innovative therapies, pharmaceuticals, medical products, and structural changes of health systems.
- understand basic data structures of health systems, in particular in the Austrian setting.
- understand the concept and importance of PICO (population-intervention-comparator-outcomes) questions.
- understand how different modeling methods are applied in HTA.
- are able to properly select a suitable modeling approach dependent on the given HTA problem.
- are able to perform a modeling and simulation study for the assessment of health technologies, including data acquisition, implementation, model parameterization, and experiments.

Non-technical competencies: Modeling and simulation has always been an interdisciplinary field of research combining mathematics, computer science, and the respective application

discipline. In this module, students work on modeling and simulation projects counseled by experts in the fields of public health, health technology assessment, and epidemiology. These experts have been actively involved in scientific decision support in the Austrian healthcare system for many years and know the peculiarities and structure of the system as well as the challenges of data availability, quality, and acquisition.

In terms of ethics, this module focuses primarily on the transparent and scientifically sound conduct of modeling and simulation studies. In the field of public health in particular, which is characterised by the many interests of different players, e.g., the federal government, state governments, doctors and their associations, hospitals and their associations, and pharmaceutical companies, conflicts of interest can quickly arise. This makes it all the more important to define the research questions of the conducted studies in a neutral manner and also provide open-ended results covering several outcome dimensions from various perspectives. Interpretation and discussion must always, in case of doubt, take human health over economic and strategic interests.

Content:

- General introduction to modeling and simulation (M&S) as a scientific method
- Introduction to M&S terminology, classification of subdisciplines, and the general modeling and simulation workflow (simulation circle).
- In-depth discussion on the modeling approaches, system dynamics, discrete event simulation, cellular automata, agent-based modeling, Markov modeling, as well as modeling and simulation with difference and differential equations
- Implementation of models using different programming environments (e.g. Python) and simulators (e.g. AnyLogic).
- Introduction to techniques for analysis of conceptual models and experimental design for M&S studies
- In-depth discussion on Health Technology Assessment (HTA) and Comparative Effectiveness Research (CER) studies
- Introduction to the Austrian health-care system and data landscape
- Current practice and application of M&S for analysis of the introduction of innovative therapies, pharmaceuticals, and medical products into health systems, including ethical and legal aspects

Expected prerequisites:

- Basic programming skills (e.g., Python, MATLAB, or similar).
- Basic university-level Math courses, in particular fundamental knowledge about differential equations, matrix calculus, probability theory, and statistics.

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 VU Modeling and Simulation

3,0/2,0 VU Modeling and Simulation in Health Technology Assessment

Neuroinformatics

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- understand how neural populations encode information about the world,
- know the state of research in modeling the dynamics of neural populations with Neural Network models,
- derive low-dimensional latent representations to interpret processes in the brain,
- understand how consistent latent representations are derived to generalize knowledge and decoders independently of individuals,
- use advanced Machine Learning tools for modeling neural population dynamics,
- formulate research questions and develop appropriate methodologies to answer them,
- implement various neural network models for cognition and motor skills,
- analyze spike patterns of individual neurons from neural populations,
- program neural decoders to control Brain-Machine Interfaces.

Non-technical competencies: In addition, students acquire interdisciplinary competencies for research and development at the interface of neuroscience, Machine Learning, and medical engineering. They can transparently justify complex methodological decisions (e.g., model selection, training/validation strategy, interpretation approaches), communicate results in a target-audience-appropriate manner (e.g., to neuroscience and technical partners), and critically reflect on limitations and uncertainties of data and models.

Content:

- Brief introduction to neural network models of the brain.
- Neural coding theory: single neuron coding, temporal and rate codes, population coding, theory of efficient coding.
- "Computation by dynamics" perspective: modeling neural population dynamics with recurrent neural networks.
- Latent neural representations: inference of latent variables of population activity using supervised and unsupervised representation learning methods.
- Interpretation of motor and cognitive computations using latent variables.
- Neural decoding algorithms for motor and speech: applications in brain-machine interfaces.
- Generalization of latent states: inferring consistent latent variables and transferring them between individuals.

- Computational analogies between human and artificial learning.

Expected prerequisites: Basic knowledge in linear algebra (vector spaces), calculus (ordinary differential equations), and statistics (independence, Bayes' theorem) is required. Basic knowledge in deep learning (loss functions, multilayer perceptron, bias-variance trade-off) as well as average Python programming experience (e.g., PyTorch and/or TensorFlow), especially in training neural networks, is helpful. Basic knowledge in neuroscience is helpful but not required.

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 Neuroinformatics (MUW)

Practice of Medicine

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are able to identify, explain, and classify the most important concepts, principles, and methods of clinical medicine. Their knowledge includes current standards of patient care and the requirements for modern IT systems in clinical environments. In particular, students can:

- correctly apply medical nomenclature and terminology (prefixes, suffixes, anatomical basics).
- outline the clinical workflow (patient journey) from admission through diagnostics to discharge.
- place evidence-based medicine (EBM) methods and clinical guidelines in the context of decision support.
- differentiate medical documentation and coding systems (such as ICD, OPS, and DRG) for data processing.
- name the essential diagnostic methods (laboratory, microbiology, imaging methods, genetics, etc.) and explain their technical foundations.
- describe basic histological techniques for representing fine tissue morphology and pathomorphology (staining methods, microscopy).
- assess the role of molecular pathology in modern diagnostics.
- derive usability and patient safety requirements from clinical reality.
- assess ethical and legal frameworks (e.g., Medical Devices Act, data protection) in medical practice.

Non-technical competencies: Students learn to work in interdisciplinary teams and communicate effectively with clinical staff (physicians, nurses). Furthermore, they are able

to discuss issues related to ethics, gender, and diversity in the context of patient care. This includes considering fairness in diagnostic algorithms and the inclusive design of clinical information systems for different user groups.

Content:

- Structure of the healthcare system: outpatient vs. inpatient sector.
- Medical specialties (conservative and surgical fields), their competencies and areas of application, conventional medicine vs. alternative medicine.
- Clinical decision-making and "clinical reasoning", medical history, differential diagnosis.
- Processes of medical documentation and billing.
- Medical terminology: structure of technical terms.
- Classification and coding (ICD-10, SNOMED CT, etc.).
- Diagnostic processes (laboratory diagnostics, microbiology, diagnostic pathology, radiology, electrophysiology, genetic diagnostics, etc.)
- Therapeutic processes (medication, surgical procedures, care planning, behavioral therapy, etc.)
- Patient safety, risk management, and quality management.
- Legal foundations (data protection, liability regulations, pharmaceutical and medical device laws, etc.) and medical ethics in the digital age.
- Practical examples: analysis of IT challenges in clinical routine (e.g., rounds, OR management).

Expected prerequisites: Basic knowledge of anatomy, physiology, and pathology from the module "Biological Basis of Disease".

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 Practice of Medicine (MUW)

Project in Medical Informatics

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- identify the background knowledge from Medical Informatics 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 (considering the state of the art and critically reflecting the solution).
- select suitable formal, mathematical, and methodological approaches for model building, abstraction, solution finding and evaluation.
- use appropriate technologies, software tools, health-data standards and clinical informatics methods to solve the task.
- thoroughly analyze the results and compare them 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, diversity, and health-data privacy and patient safety in the context of the module's content.

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

- Technical specification of a task from Medical Informatics.
- 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:

6,0/4,0 PR Project in Medical Informatics

Prosthetics and Control Theory

Workload for the module: 6,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, students are familiar with the most important medical fundamentals in the field of amputations, as well

as surgical, therapeutic, and technical care of affected patients. They also have an understanding of the functioning and application areas of neuroprosthetics (functional electrical stimulation, neuromodulation), with a focus on movement rehabilitation, among other things after spinal cord injury. Furthermore, they have basic knowledge of medical control engineering, understand the difference between open-loop and closed-loop control, can apply these to medical devices, and implement simple control algorithms. They can link this theoretical knowledge with specific questions of medical informatics. In particular, students can:

- explain the difference between open-loop control and closed-loop control and apply it to medical devices.
- explain fundamentals and application examples of medical control engineering.
- mathematically model and analyze linear dynamic systems in the medical context.
- design classical controllers (e.g., PID controllers) for medical applications and assess their stability.
- independently develop computer programs for the control of medical devices.
- name reasons for limb amputations and describe their impact on the lives of those affected.
- describe care options as well as their advantages and disadvantages.
- link existing knowledge and skills from the field of bio-signals with questions from prosthesis control.
- identify current trends and research areas in the field of prosthetics and discuss solution approaches from the field of informatics.
- explain the physiological and technical backgrounds of functional electrical stimulation and its mechanisms of action, referring to stimulator technology, parameters, electrodes, and application safety.
- describe interdisciplinary collaboration in the field of electrical stimulation and contribute to clinical discussions.
- describe safety measures and contraindications of electrical stimulation.
- identify areas of work in medical informatics using knowledge of the historical development and current research in electrical stimulation.

Non-technical competencies: In addition, students acquire competencies for the practice-oriented development and evaluation of prosthetic and control engineering systems in the medical context. They learn to communicate purposefully in interdisciplinary teams (e.g., medical technology, computer science, physiotherapy, physicians, orthopedic technology), to gather requirements from clinical and patient-centered perspectives, and to justify technical decisions in a traceable manner. This also includes academic work (critical literature research, clean documentation, and reproducibility of implementations), as well as structured problem-solving and project work (iterations, test and evaluation planning). A special focus is on the responsible handling of safety-critical systems: students reflect on ethical aspects (autonomy, participation, fairness, dealing with vulnerability), data protection in bio-signal-based applications, as well as risks and limitations of control approaches (e.g., malfunctions, overfitting, robustness in everyday use) and can derive measures for risk minimization and safe application.

Content: The module is thematically divided into the medical-therapeutic fundamentals of prosthetics and the technical implementation of control systems. The module consists of two parts:

Part 1 — Prosthetics:

- Types and causes of amputations.
- Medical-therapeutic approach to amputations.
- Technical possibilities in prosthetics.
- Self-experience through testing of prostheses/therapy concepts in prosthetics.
- Basic concepts and mechanisms of action of functional electrical stimulation.
- History of medical electrical stimulation.
- Application examples of nerve and muscle stimulation in different disease patterns, with a focus on movement rehabilitation, among other things after spinal cord injury.
- Practical fundamentals for clinical testing and therapy planning, as well as outpatient and telemedical care of home applications of functional electrical stimulation.
- Self-experience with stimulation techniques and mechanisms of action.

Part 2 — Control Engineering in Medicine:

- Fundamentals of systems theory: definition of system, input, output, and state.
- Distinction between open-loop control and closed-loop control.
- Modeling of dynamic systems: differential equations and transfer functions.
- Analysis of linear systems in the time and frequency domain.
- Feedback and stability criteria.
- Design and implementation of controllers (P, PI, PID) for medical actuators.
- Introduction to digital control systems (discrete-time systems) for implementation in software.

Expected prerequisites: Fundamentals of biosignal processing (from the module Biosignals and Medical Imaging), mathematical fundamentals (especially differential calculus and complex numbers). Basic knowledge in programming (e.g., Python or MATLAB) is advantageous.

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 VU Prosthetics (MUW)

3,0/2,0 VU Control Theory in Medicine (MUW)

Public Health Policy and Healthcare Management

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- explain basic concepts and central models of public health policy (including system design, target groups, prevention, integrated care) and apply them to concrete questions.
- describe structures and functions of health systems and comparatively analyze design options (governance, financing, service provision, regulation).
- explain societal and social determinants of health and incorporate them into the planning of public health measures.
- explain management and organization theories and concepts and derive their significance for health systems and organizations (including special features such as NPO management).
- analyze processes, structures, and organizational workflows in the health sector and derive requirements for (medical) informatics solutions from them.
- classify the role of MIS, CIS, and information technologies in the context of central management processes and critically evaluate their benefits and limitations.
- conceptually develop new forms of care and prevention measures and assess their feasibility considering stakeholders, resources, and framework conditions.

Non-technical competencies: In addition, students acquire interdisciplinary competencies for interdisciplinary collaboration in the health and social policy context. They can analyze complex problems in a structured way, understand the positions of different professional groups and stakeholders, and communicate results in an audience-appropriate manner (e.g., as short policy/management memos or presentations). They strengthen skills in critical thinking, discussion and moderation, as well as project-oriented work. Furthermore, they reflect on ethical and societal dimensions of decisions in public health and health care management (e.g., equity, transparency, conflicts of interest) and can adequately present uncertainties and limitations of the underlying evidence.

Content: The module consists of two parts:

Part 1 — Public Health Policy:

- Design options for health systems: goals, actors, institutions, and control instruments.
- Societal and social determinants of health and their significance for public health strategies.
- Public health care, Public Health, definition/accessibility of target groups.
- Planning, design, and implementation of prevention measures; monitoring and further development.

- Integrated care and new forms of care: development, implementation, and framework conditions.
- Application fields of medical informatics in the public health context (developed jointly).

Part 2 — Health Care Management:

- Introduction to management and organization theories and concepts.
- Special features of the management of health systems and organizations (e.g., NPO management).
- Processes, structures, and organizational workflows in health care management (planning, coordination, control, quality).
- MIS, CIS, and information technologies as support for management processes: classification, benefits, limitations.
- Problems, open questions, and possible limits of IT-supported management approaches in health care.

Expected prerequisites: No special prerequisites required.

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 VO Public Health Policy (MUW)

3,0/2,0 VO Health Care Management (MUW)

Responsible Digital Ethics

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- understand key concepts of digital ethics, including trust, fairness, accountability, and digital rights
- recognize and apply regulatory frameworks and their implications for ethical digital practices
- evaluate ethical design principles in the development and deployment of digital systems

Non-technical competencies:

- analyze real-world digital ethics challenges using case studies and scholarly literature
- critically evaluate ethical trade-offs in complex technological environments

- create actionable strategies to incorporate ethical principles into the design, audit, and deployment of digital systems
- understand and reflect on personal and professional responsibilities as practitioners shaping the digital landscape
- apply effective communication strategies about ethical challenges and solutions to diverse audiences
- Design and implement frameworks for ethical practices in interdisciplinary and organizational contexts

Furthermore, students will be able to identify, articulate, and discuss issues concerning ethics, gender, and diversity in the context of the module's content. Ethics, Gender, and Diversity in Responsible Digital Ethics are addressed through the exploration of fairness, accountability, and digital rights in technological systems. The module equips students with the ability to evaluate ethical trade-offs, regulatory frameworks, and biases, ensuring inclusive and responsible digital practices. Case studies and ethical design principles help students develop strategies for embedding ethical considerations into real-world digital systems.

Content:

- Introduction to Digital Ethics: The rise of digital systems and the imperative for ethical practices.
- Core Principles: Trust, fairness, accountability, transparency, and digital rights.
- Ethical Design: Principles and methodologies for designing ethical systems.
- Regulatory Landscapes: Overview of regulatory efforts and their impact on system performance and ethical audits.
- Practical Challenges: Case studies on ethical dilemmas in digital technology (e.g., AI bias, privacy concerns, algorithmic accountability).
- Roles and Responsibilities: The critical role of practitioners in fostering responsible digital ethics.

Expected prerequisites:

- Basic knowledge of ethical theories and frameworks
- Basic knowledge of regulatory frameworks and policies

These prerequisites are taught in the module *Denkweisen der Informatik* of the *Informatics* bachelor program.

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 Responsible Digital Ethics

Seminar in Medical Informatics

Workload for the module: 3,0 ECTS

Learning Outcomes:

Technical competencies: After successful completion of the module, 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 Medical Informatics. 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 Medical Informatics.

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.
- Students 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, patient representation, and diversity in health data and clinical decision-making systems. Aspects such as bias in employed AI models, equitable access to digital health tools, patient privacy, or ethical concerns in the use of AI for diagnostics and treatment planning can be addressed depending on the chosen topic.

Content: In the seminar, students dive deeper into the literature of one chosen topic in Medical Informatics (e.g., Bioinformatics, Neuroinformatics, Public Health Informatics, etc.) 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 Medical Informatics

Standardized Health Information Management

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- correctly classify and relate basic concepts in the conceptual environment of Electronic Health Records
- explain the modeling approach commonly used in Electronic Health Record standards in two separate levels
- practically apply the two-level approach for modeling health data that is compliant with the HL7 Clinical Document Architecture and HL7 FHIR standards
- describe the structure and content of standardized clinical information models that play a central role in national and international eHealth implementations
- characterize the most important resource types of the HL7 FHIR standard and describe their interaction
- differentiate the types of exchange of FHIR-compliant health data using the functions of the RESTful API
- gain an overview of clinical classifications, terminologies, and ontologies for interoperability and AI in healthcare; understand the structure of the OMOP Common Data Model and the associated methods and concepts
- describe the typical process of transforming health data into the OMOP Common Data Model
- understand the purpose and use of important software tools in the OMOP Common Data Model environment
- know the lifecycle of image data in the medical environment and the underlying processes associated with it
- identify problems related to medical image management and apply the taught methods to solve these problems
- have knowledge of the essential standards for image management currently used in digital medicine
- gain knowledge about general medical image archiving solutions

Non-technical competencies: Students gain an overview of which international standardization organizations are active in the field of Medical Informatics and how their specifications manifest in the representation of health data. They learn what prerequisites

need to be created and what preliminary work is required to establish a practical network for the exchange of harmonized health data.

Content:

- Electronic Health Record and conceptual environment according to ISO definitions
- Modeling of standardized Electronic Health Records using the two-level approach
- Implementation of the two-level approach in the HL7 Clinical Document Architecture standard
- Implementation of the two-level approach in the HL7 FHIR standard
- Examples of standardized clinical information models in national and international contexts
- Resource types in the HL7 FHIR standard
- The RESTful API in the HL7 FHIR standard
- Important eHealth terminology standards
- Introduction to the secondary use of health data in general and the OMOP Common Data Model in particular
- Central steps in the "Extract-Transform-Load" process of health data into the OMOP Common Data Model
- Central open source tools in the OMOP Common Data Model environment
- Introduction to the concept of "Picture Archiving and Communication Systems" (PACS) and the "Digital Imaging and Communications in Medicine" (DICOM) standard)
- Presentation of the data model underlying the DICOM standard
- Encoding methods for representing the entities of this data model and data storage according to DICOM
- Data exchange and interfaces according to the DICOM standard
- Image systematics in medical image archiving

Expected prerequisites: "Introduction to Digital Health", basic knowledge in programming, database queries (SQL), and HTTP/REST queries.

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:

- 1,5/1,0 VU Standardized electronic health records modeling (MUW)
- 1,5/1,0 VU Standardized health information exchange and terminologies (MUW)
- 1,5/1,0 VU Standardized common data models for secondary use (MUW)
- 1,5/1,0 VO Medical image management standards (MUW)

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

Wellbeing Technologies

Workload for the module: 6,0 ECTS

Learning Outcomes:

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

- Apply design and evaluation methods tailored to wellbeing technologies.
- Prototype interfaces that foster physical and mental wellbeing.
- Utilise sports sensors, motion tracking, and physiological sensing in the development of wellbeing technologies.
- Address ethical considerations in the design and deployment of health-related technologies

Non-technical competencies:

- Analyse and integrate theoretical concepts of wellbeing, personal informatics, and physical activity into technology design.
- Critically evaluate the impact of technology on wellbeing, with a focus on ethical implications and user needs.
- Develop innovative, user-centred solutions for promoting healthy behaviours.
- Understand the complexities and responsibilities associated with designing technologies for health and wellbeing.
- Reflect on their own role as designers of technologies that influence wellbeing and lifestyle choices.
- Collaborate effectively in interdisciplinary teams to address design challenges related to wellbeing.
- Communicate design concepts, ethical considerations, and evaluation outcomes to diverse audiences.

Weiters können die Studierenden Fragestellungen von Gender, Ethik und Diversität im Kontext der Inhalte des Moduls identifizieren, formulieren und diskutieren.

Content:

- Introduction to Wellbeing Technologies: Foundations of wellbeing, personal informatics, and healthy lifestyles.
- Design Principles: Methods and strategies for designing technologies that promote wellbeing.
- Ethics and Responsibility: Exploring ethical frameworks and the responsibilities of designers working with health-related technologies.
- Evaluation Methods: Approaches to assessing the impact and ethical implications of wellbeing technologies.
- Prototyping and Tools: Hands-on work with sports sensors, motion tracking, and physiological sensing.
- Practical Challenges: Case studies and examples of wellbeing technologies, focusing on their design, ethical implications, and use.

- Applications: Exploring technologies that encourage physical activity, healthy habits, and mental wellbeing.

Expected prerequisites:

- Experience with design tools and prototyping of interactive systems
- Fundamentals of ubiquitous computing
- Experience in conducting quantitative and qualitative user studies

Mandatory requirements: Inskription des Masterstudiums.

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 Wellbeing Technologies

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 D) und aus dem zentralen Wahlfachkatalog der TU Wien für "Transferable Skills" empfohlen.

B Semester Scheduling of the courses

Students are advised, upon entering the Master's programme — preferably in the first or second semester — to complete the modules of the examination subject *Foundations of Medical Informatics*, as these provide the academic basis for the remainder of the programme. The third semester is particularly suitable for a semester abroad.

C Examination subjects with their assigned modules and courses

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

Examination Subject “Foundations of Medical Informatics” (30 ECTS)

Module “Advanced Software Engineering in the Biomedical Context” (6,0 ECTS)

3,0/2,0 VU Advanced Software Engineering in the Biomedical Context (MUW)

3,0/2,0 PR Advanced Software Engineering in the Biomedical Context (TUW)

Module “Biological Basis of Disease” (6,0 ECTS)

3,0/2,0 VU Biological Basis of Disease, Part I: Anatomy and Histology (MUW)

3,0/2,0 VU Biological Basis of Disease, Part II: Physiology and Pathology (MUW)

Module “Introduction to Medical Data Science and Analytics” (6,0 ECTS)

3,0/2,0 VU Statistical Basis of Medical Data Science (MUW)

3,0/2,0 VU Foundations of Medical Machine Learning (TUW)

Module “Introduction to Digital Health” (6,0 ECTS)

3,0/2,0 VU Digital Health Foundations and Data Governance (MUW)

3,0/2,0 VU Human-Computer Interaction for Health and Wellbeing (TUW)

Module “Practice of Medicine” (6,0 ECTS)

6,0/4,0 VU Practice of Medicine (MUW)

Examination Subject “Biological and Medical Principles”

***Module “Bioinformatics” (6,0 ECTS)**

6,0/4,0 VU Bioinformatics (MUW)

***Module “Computational Neuroscience” (6,0 ECTS)**

6,0/4,0 VU Computational Neuroscience (MUW)

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

3,0/2,0 VO Introduction to Molecular Biology, part 1 (MUW)

3,0/2,0 VO Introduction to Molecular Biology, part 2 (MUW)

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

4,0/2,5 VO Introduction to Neuroscience (MUW)

2,0/1,5 SE Introduction to Neuroscience (MUW)

***Module “Neuroinformatics” (6,0 ECTS)**

6,0/4,0 VU Neuroinformatics (MUW)

***Module “Prosthetics and Control Theory” (6,0 ECTS)**

3,0/2,0 VU Prosthetics (MUW)

3,0/2,0 VU Control Theory in Medicine (MUW)

Examination Subject “Data, Policy, and Health Informatics”

***Module “Advanced Database Systems” (6,0 ECTS)**

6,0/4,0 VU Advanced Database Systems

***Module “AI Ethics” (6,0 ECTS)**

6,0/4,0 VU AI Ethics

***Module “Data Stewardship” (6,0 ECTS)**

3,0/2,0 VO Data Stewardship

3,0/2,0 UE Data Stewardship

***Module “Methodological Foundations of Public Health Informatics” (6,0 ECTS)**

3,0/2,0 VU Outcomes Research (MUW)

3,0/2,0 VU Epidemiology (MUW)

***Module “Public Health Policy and Healthcare Management” (6,0 ECTS)**

3,0/2,0 VO Public Health Policy (MUW)

3,0/2,0 VO Health Care Management (MUW)

***Module “Responsible Digital Ethics” (6,0 ECTS)**

6,0/4,0 VU Responsible Digital Ethics

***Module “Standardized Health Information Management” (6,0 ECTS)**

1,5/1,0 VU Standardized electronic health records modeling (MUW)

1,5/1,0 VU Standardized health information exchange and terminologies (MUW)

1,5/1,0 VU Standardized common data models for secondary use (MUW)

1,5/1,0 VO Medical image management standards (MUW)

Examination Subject “Machine Learning and Intelligent Health Systems”

***Module “Advanced Machine Learning in Healthcare” (6,0 ECTS)**

3,0/2,0 VU Advanced Machine Learning in Healthcare: Part 1 (TUW)

3,0/2,0 VU Advanced Machine Learning in Healthcare: Part 2 (MUW)

***Module “Medical Signal Processing and Imaging” (6,0 ECTS)**

3,0/2,0 VU Biosignal Processing (MUW)

3,0/2,0 VU Medical Imaging and Image Processing (MUW)

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

6,0/4,0 VU Computer Vision

***Module “Generative AI, General AI” (6,0 ECTS)**

6,0/4,0 VU Generative AI, General AI (MUW)

***Module “Logic-based Artificial Intelligence” (6,0 ECTS)**

6,0/4,0 VU Logic-based Artificial Intelligence

***Module “ML in Medical Imaging and Precision Medicine” (6,0 ECTS)**

6,0/4,0 VU ML in Medical Imaging and Precision Medicine (MUW)

***Module “Modeling and Simulation for Medical Informatics” (6,0 ECTS)**

3,0/2,0 VU Modeling and Simulation

3,0/2,0 VU Modeling and Simulation in Health Technology Assessment

Examination Subject “Human-Centered Technologies and Visualization in Healthcare”

***Module “Artifact-based Design” (6,0 ECTS)**

6,0/4,0 VU Artifact-based Design

***Module “Assistive Technologies” (6,0 ECTS)**

6,0/4,0 VU Assistive Technologies

***Module “Human-Centered AI” (6,0 ECTS)**

6,0/4,0 VU Human-Centered AI

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

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

***Module “Wellbeing Technologies” (6,0 ECTS)**

6,0/4,0 VU Wellbeing Technologies

Examination Subject “Free Electives”

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

Examination Subject “Seminar, Project, and Advanced Topics in Medical Informatics”

Module “Seminar in Medical Informatics” (3,0 ECTS)

3,0/2,0 SE Seminar in Medical Informatics

Module “Project in Medical Informatics” (6,0 ECTS)

6,0/4,0 PR Project in Medical Informatics

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

Examination Subject “Master’s thesis”

1,5/1,0 SE Seminar für Diplomand_innen

27,0 ECTS Diplomarbeit

1,5 ECTS Kommissionelle Abschlussprüfung

D Wahlfachkatalog "Transferable Skills"

Die Lehrveranstaltungen, die im Modul *Freie Wahlfächer und Transferable Skills* aus dem Themenbereich "Transferable Skills" zu wählen sind, können unter anderem aus dem folgenden Katalog gewählt werden.

- 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