Module Guide
Master Intelligent Robotics

Faculty Applied Natural Sciences and Industrial Engineering
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MIR-1 Robotic Dynamics

Module code	MIR-1
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1101 Robotic Dynamics
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Robot Dynamics is an advanced course that delves into the mathematical and mechanical foundations governing the movement and control of robotic systems. This course provides students with a comprehensive understanding of the principles, equations, and methodologies used in modeling and controlling the dynamic behavior of robots.
It covers both theoretical aspects and practical applications, with a focus on rigid body dynamics and motion control. The Robot Dynamics course is designed to provide students with a deep understanding of the principles and concepts related to the dynamics of robotic systems. This advanced-level course covers both theoretical foundations and practical applications in the field of robot dynamics. Students will explore the mathematical modeling of robot motion, the analysis of forces and torques, and the control of robotic

movement. The course focuses on rigid body dynamics, which are fundamental for various applications, including industrial automation, aerospace, medical robotics, and autonomous systems.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Develop a strong comprehension of the core principles and theoretical foundations governing the dynamics of robotic systems.
- Apply mathematical modeling techniques to accurately describe the dynamic behavior of robot manipulators, taking into account factors such as mass distribution, inertia, and external forces. o Formulate dynamic equations of motion for robotic systems using advanced methods, including Lagrange's equations, to understand how forces and torques affect robot movement.
- Ensure the safety and reliability of robotic systems.

Methodological competence:

- Students will be able to translate real-world robot dynamics into mathematical equations and analyze them methodically.
- Competence in interpreting data and drawing meaningful conclusions from experimental results is developed.
- Design various control strategies, such as PID control, robust control, and feedback linearization. These competences are vital for effectively governing robot motion and improving control performance.

Personal competence:

- Personal competences such as adaptability and flexibility will be nurtured as students learn to adjust to changing circumstances and technological advancements in the field of robotics.
- Students will cultivate a personal problem-solving mindset, which is important for addressing challenges in complex robotic systems.

Social competence:

- Collaboratively solving complex problems related to robot dynamics is a social competence that involves brainstorming, sharing ideas, and building consensus on solutions.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of robot dynamics in dynamic action and applications, specifically in AI based control. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

This module elaborates on the fundamental Artificial Intelligence (AI) concepts and establishes the correlation to intelligent sensor/actuator systems.

- Kinematics o Rigid body dynamics.
- Robot dynamics modelling
- Control of Robot Dynamics
- Trajectory planning and path generation
- Dynamics simulation and Software tools
- Force control o Vision servoing
- Grasping and manipulation
- Wheeled mobile robots
- Redundant Robots and Singularities
- Dynamics in Non-Cartesian Coordinates
- Advanced control strategies (e.g. Model Predictive Control)

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar.

[2]. "Modern Robotics: Mechanics, Planning, and Control" by Kevin M. Lynch and Frank C. Park.

[3]. Robotics, Planning and control, by Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe Oriolo.

[4]. Springer Handbook of Robotics, by Bruno Siciliano and Oussama Khatib (Editors).

[5]. "Introduction to Robotics: Mechanics and Control" by John J. Craig.

MIR-2 Advanced Methods in Control Engineering

Module code	MIR-2
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1102 Advanced Methods in Control Engineering
Lecturer	Tobias Schaffer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Advanced control engineering is a specialized field within the broader discipline of control engineering that focuses on the development and application of sophisticated control techniques for complex systems. In advanced control engineering, engineers and researchers work on designing control systems that go beyond basic proportional-integral-derivative (PID) control. These systems are capable of handling intricate, nonlinear, time-varying, and uncertain processes, often involving high-performance, precision, and safety requirements. An Advanced Methods in Control Engineering course delves into modern techniques and tools used in the design and analysis of control systems. It focuses on advanced control theories, algorithms, and methodologies that enable engineers to tackle complex control problems and achieve superior performance. This course provides a structured path through advanced control engineering concepts and practical applications. The course includes a combination of theoretical lectures, hands-on exercises and case studies to ensure that students gain a strong foundation in advanced control theory and its real-world applications.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competences:

- Deep understanding of advanced control methods, enabling them to design complex control systems for a wide range of applications.
- Applying optimization techniques to control systems, resulting in improved performance and efficiency.
- Proficiency in controlling nonlinear systems, which are common in real-world applications, leading to more versatile control strategies.
- The capability to develop adaptive control systems that can self-adjust to changing system conditions and parameters.
- Design control systems that are robust to uncertainties and external disturbances, enhancing system reliability.

Methodological competence:

- ability to create accurate mathematical models of dynamic systems, which is crucial for control system design.
- skill to conduct both simulations and real-world experiments to validate control system designs.
- Improved analytical and problem-solving skills for addressing complex control challenges.
- The ability to conduct literature reviews to stay updated with the latest research and emerging trends in control engineering.
- Competence in using advanced control software and simulation tools to model, analyze, and optimize control systems.

Personal competence:

- manage complex control system projects, from inception to implementation, including time management and resource allocation.
- Improved ability to communicate complex control concepts and designs effectively with both technical and non-technical stakeholders.
- Encouragement to think creatively and innovatively when designing control systems for various applications.

Social competence:

- Proficiency in building professional networks with peers, mentors, and industry professionals to stay informed about current trends and to explore career opportunities.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of advanced control engineering methods in various application scenarios. It creates interfaces to courses of study such as mechatronics, computer science, robotics, automation.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

"Advanced Methods in Control Engineering" course covers advanced control theory, techniques, and applications. This type of course is typically offered at the postgraduate level and assumes a foundational understanding of control engineering concepts. Topics in this course are:

- Introduction to Advanced Control.
- State-Space Representation.
- Optimal Control.
- Robust Control.
- Nonlinear Control.
- Adaptive Control.

Furthermore, this course covers system identification in the control applications (e.g. under disturbances):

- least square method.
- Kalman filtering.
- disturbance estimation and cancellation.

Also, this course considers discrete time control.

- Transitioning from continuous-time to discrete-time control.
- Discrete-time state-space representation.
- Discretization of continuous-time controllers.

This course concludes with NN (neural network)-based control methods:

- Neural Network-Based Control Concepts..
- Recurrent Neural Networks in Control
- Reinforcement learning.

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application.

- i-Learn (online learning platform).

Recommended Literature

[1]. "Nonlinear Systems" by Hassan K. Khalil

[2]. "Model Predictive Control: Theory and Design" by James B. Rawlings and David Q. 9 Mayne

[3]. "Optimal Control Theory: An Introduction" by Donald E. Kirk

[4]. "Neural Network Control of Nonlinear Discrete-Time Systems" by K. S. Narendra and Anudeepthi V. Kadali

MIR-3 Statistics and Machine Learning

Module code	MIR-3
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1103 Statistics and Machine Learning
Lecturer	Tobias Schaffer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

"Statistics and Machine Learning" course is typically designed to teach students the principles, methods, and techniques of both statistics and machine learning, and how these disciplines are used to analyze data and make predictions. The course covers a wide range of topics related to data analysis, modeling, and predictive analytics. Upon completion of this course, the student has achieved the following learning objectives:

Professional competence:

- Students will become proficient in data analysis, including data cleaning, preprocessing, and deriving meaningful insights from data.
- Competence in building predictive models for both regression and classification tasks, as well as time series forecasting.

- The ability to implement machine learning algorithms and deep learning models using popular libraries like scikit-learn, TensorFlow, and PyTorch.
- Understanding how to draw conclusions from data, perform hypothesis testing, and estimate population parameters.
- Proficiency in evaluating the performance of machine learning models using appropriate metrics and cross-validation techniques.
- Skill in creating informative and visually appealing data visualizations to present findings effectively.

Methodological competence:

- The capability to define research problems, formulate hypotheses, and devise data-driven solutions.
- Competence in designing experiments and data collection strategies for research or business purposes.
- To engineer new features from existing data to improve model performance.
- Understanding techniques for reducing the dimensionality of data while preserving important information.
- Competence in analyzing and modeling time series data for forecasting applications.

Personal competence:

- Development of critical thinking skills for assessing the validity and applicability of statistical and machine learning methods to different problems.
- The ability to adapt to evolving data analysis and machine learning techniques, tools, and frameworks.
- Fostering the capability to continue learning independently, keeping up with the latest developments in the field.
- Developing a sense of ethical responsibility in data handling and model development, including understanding issues related to bias and fairness.

Social competence:

- Effective communication of data analysis results, findings, and predictions to both technical and non-technical stakeholders.

Applicability in this and other Programs

Application of statistical and probability theory in robot perception. Course is also applicable for various AI-related master degree programs.

Entrance Requirements

Bachelor`s degree in mechatronics or a closely related field.

Learning Content

The course is designed to be hands-on, with practical exercises and projects where students apply statistical and machine learning techniques to analyze data and solve real-world problems. It's important for students to gain both theoretical knowledge and practical skills, as these are highly sought after in data analysis and machine learning roles in various industries, including finance, healthcare, marketing, and more. Topics in this course are:

- Introduction to Statistics and Machine Learning
- Descriptive Statistics o Probability and Probability Distributions
- Statistical Inference
- Linear Regression
- Classification Algorithms
- Bayesian Methods
- Clustering and Unsupervised Learning
- Feature Selection and Engineering
- Introduction to Machine Learning Frameworks
- Model Evaluation and Validation o Natural Language Processing (NLP)
- Anomaly Detection and Outlier Analysis
- Generative adversarial networks (GANs)
- Time Series Forecasting with Machine Learning
- Big Data and Distributed Machine Learning

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Introduction to the Practice of Statistics" by David S. Moore, George P. McCabe, and Bruce A. Craig.

[2]. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy.

[3]. "Introduction to Machine Learning with Python: A Guide for Data Scientists" by Andreas C. Müller & Sarah Guido.

[4]. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

MIR-4 Technical Project Management

Module code	MIR-4
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1104 Technical Project Management
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The Technical Project Management course is designed to equip students with the essential knowledge and skills needed to successfully plan, execute, and manage technical projects in various domains. This course integrates project management principles with a focus on technical aspects, providing students with the tools to effectively lead and execute projects that involve technology, engineering, or scientific components. Students will learn to balance technical requirements, project scope, timelines, and resource management to deliver successful outcomes. After completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Competence in planning, executing, and overseeing complex technical projects from initiation to closure, including resource allocation and risk management.
- An understanding of the technical aspects of projects, allowing students to make informed decisions and effectively communicate with technical experts.
- Competence in ensuring that project deliverables meet defined quality standards and that quality control measures are effectively implemented. o Ability to handle changes in project scope and requirements effectively, making adjustments while minimizing disruptions to project progress.
- Understanding of agile methodologies and their application in technical projects, promoting adaptability and flexibility

Methodological competence:

- Competence in defining project objectives, scope, and requirements, creating project plans, and managing the project schedule and budget.
- Ability to identify, assess, and mitigate project risks, as well as develop contingency plans to minimize the impact of unexpected events.
- Competence in identifying and analyzing stakeholders, understanding their needs, and effectively communicating with project teams and stakeholders.
- Ability to evaluate and select vendors, manage contracts, and ensure vendor performance aligns with project goals.
- Proficiency in maintaining comprehensive project documentation, providing transparent reporting to stakeholders, and conducting project closure activities.

Personal competence:

- Development of critical thinking skills for assessing project challenges, making informed decisions, and solving complex technical problems.
- The ability to adapt to evolving project requirements, methodologies, and changing project conditions.
- Understanding and applying ethical principles in project management, particularly concerning data privacy, diversity, and inclusion.
- Improved time management skills to meet project deadlines and manage competing priorities effectively.

Social competence:

- Building relationships with industry peers and experts, creating opportunities for professional growth and knowledge exchange.
- The skill to assess project outcomes, identify areas for improvement, and implement continuous improvement strategies in future projects.

Applicability in this and other Programs

The module provides the necessary theoretical background and transfer possibility for the technical project management and team cooperation. Interfaces to any technically related programmes.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

This extended Technical Project Management course offers students an opportunity to thoroughly understand and apply project management principles within a technical context. It places a strong emphasis on hands-on learning, real-world case studies, and practical application, ensuring that students are well-prepared to lead and manage complex technical projects effectively. In addition, the following topics are also covered in this module:

- Project Initiation and Stakeholder Analysis.
- Project Planning and Work Breakdown Structure (WBS).
- Resource Allocation and Scheduling.
- Risk Management in Technical Projects.
- Technical Requirements and Scope Management.
- Agile Project Management in Technical Projects.
- Quality Management in Technical Projects.
- Project Documentation, Reporting, and Closure.

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application.
- i-Learn (online learning platform).

Recommended Literature

[1]. "A Guide to the Project Management Body of Knowledge (PMBOK Guide)" by Project Management Institute (PMI)

[2]. "Project Management for Engineering and Construction" by Garold D. Oberlender

[3]. "Agile Project Management with Scrum" by Ken Schwaber

[4]. "Effective Project Management: Traditional, Agile, Extreme" by Robert K. Wysocki

[5]. Project Management: A Systems Approach to Planning, Scheduling, and Controlling"
by Harold Kerzner

MIR-5 Embedded Systems

Module code	MIR-5
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1105 Embedded Systems
Lecturer	Tobias Schaffer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

An Embedded Systems course focuses on the integration of control theory with embedded systems, which are computer systems designed to perform dedicated functions within a larger mechanical or electrical system. This course emphasizes the design, implementation, and analysis of control systems that are embedded within real-world applications. Upon completion of this module, depending on a more theoretical or more practical focus, students will be able to design embedded robotic solutions including, microcontroller programming, learn common embedded systems peripherals like GPIO (General Purpose Input/Output) pins, digital and analog sensors, and actuators. This course emphasizes real-time implementation of algorithms, which is crucial for robotic systems as they act in the dynamic environments.

Professional competence:

- Developing a high level of expertise in embedded systems, microcontroller programming, and related technologies.
- Proficiency in designing and architecting embedded systems to meet specific requirements and constraints.
- Competence in programming embedded systems using C/C++ and understanding the intricacies of low-level code.
- Proficient at integrating software and hardware components for embedded systems.
- Understanding and applying real-time concepts in embedded system design, ensuring timely responses to events.

Methodological competence:

- Developing the ability to identify and troubleshoot issues in embedded systems and propose effective solutions.
- Competency in working with Real-Time Operating Systems (RTOS) for multitasking and resource management.
- Methodical approach to testing and debugging embedded systems to ensure reliability and correctness. o Skill in documenting the design, development, and testing processes effectively.
- Competence in planning and organizing embedded system projects, including resource allocation and time management.

Personal competence:

- Demonstrating flexibility in learning and adapting to new technologies and hardware platforms.
- Maintaining a high level of motivation and curiosity to explore and understand embedded systems concepts.
- Managing challenges and setbacks effectively, maintaining composure in complex problem-solving scenarios.

Social competence:

- Effectively conveying technical information and ideas to peers and team members.
- Working collaboratively with team members, respecting diverse perspectives, and achieving shared project goals.
- Skill in addressing and resolving conflicts within project teams, fostering a positive working environment.

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and the transfer capability to gain a deeper understanding of embedded solutions and the capability to apply and to evaluate hardware in and for a specific area of application. This creates interfaces to courses of study such as mechanical engineering, mechatronics, electrical engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

On the basis of a selected application example, the students should explore and work on the topic themselves by means of literature research, independent sub-tasks, etc. The topics of the case studies can be chosen from any subject area.

Topics:

- Introduction to Embedded Systems
- Microcontrollers and Microprocessors
- Embedded C Programming
- Embedded System Peripherals
- Real-Time Operating Systems (RTOS)
- Embedded System Development Tools
- Embedded System Design

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application.
- i-Learn (online learning platform).

Recommended Literature

[1]. "Embedded Systems: Introduction to ARM Cortex-M Microcontrollers" by Jonathan Valvano

[2]. "Embedded Systems: Real-Time Operating Systems for ARM Cortex-M Microcontrollers" by Jonathan Valvano

[3]. "Programming Embedded Systems in C and C++" by Michael Barr

[4]. "Real-Time Systems Design and Analysis" by Phillip A. Laplante

MIR-6 Case Study ROS Robot Programming

Module code	MIR-6
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR1106 Case Study ROS Robot Programming
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

On the basis of an application example in the case study comprehensive exploration of the Robot Operating System (ROS) and its practical application in programming and controlling robots is considered. Students will be introduced to the fundamentals of ROS, develop programming skills for robotic systems, and engage in hands-on projects that culminate in real-world robot programming applications. The course encompasses various aspects of robotics, including perception, motion planning, navigation, and manipulation.

Upon completion of this module, students will have achieved the following learning outcomes:

Professional competence:

- Develop expertise in using the Robot Operating System (ROS) to program, control, and navigate robots effectively.Acquire the skills to develop, maintain, and optimize software for robotic systems.
- Learn to integrate hardware and software components to build functional robot systems.
- Gain competence in developing motion planning algorithms for robots, enabling them to navigate and interact with their environment.
- Master techniques for sensor data processing, object recognition, and environment mapping.

Methodological competence:

- Develop the ability to identify and resolve complex issues related to robot programming and control.
- Apply scientific methodologies for robot experimentation, data collection, and analysis.
- Learn to model and simulate robots and their environments to test algorithms and strategies.
- Develop the practice of documenting project work, code, and research findings effectively.

Personal competence:

- Application of software development concepts based on the ROS framework for research and implementation of robot motion control algorithms in complex dynamic environments.
- The students learn different concepts which can be applied to deploy robotics-related applications.

Social competence:

- Develop effective communication skills to collaborate with peers and convey technical concepts to non-technical stakeholders.
- Foster teamwork and cooperation within diverse project teams, valuing diverse perspectives and contributions
- Build the capacity to resolve conflicts and disagreements constructively within the team or among project stakeholders.

Applicability in this and other Programs

The skills and competences acquired in a "ROS Robot Programming" course can be applied to a wide range of master's degree programs and fields, e.g. AI, Industrial engineering, etc.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

On the basis of a selected application example, the students should explore and work on the topic themselves by means of literature research, independent sub- tasks, etc. The topics of the case studies can be chosen from any subject area.

The topics of the case studies can vary each semester.

Teaching Methods

- i-Learn (online learning platform).
- Literature research..
- Simulations.
- Development, construction and building of robotic systems.
- Application of assessment techniques.
- Guided work on seminar topics in working groups. Accompanying events / presentations by external speakers depending on the selected topic area.

Remarks

The case studies are examined as a so-called "Prüfungsstudienarbeit" (student research report) and are therefore not a classic examination.

The theoretical knowledge acquired by the students is specifically applied in practice in the case study topics so that students analyse problems independently and apply proposed solutions. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competences by recognising connections and evaluating them.

Recommended Literature

[1]. "Programming Robots with ROS: A Practical Introduction to the Robot Operating System" by Morgan Quigley, Brian Gerkey, and William D. Smart

[2]. "Mastering ROS for Robotics Programming" by Lentin Joseph

[3]. "ROS-Industrial: An Open-Source Robot Operating System Consortium for Manufacturing Robotics" by R. Owens and B. J. Panzera

[4]. "ROS Robotics Projects" by Lentin Joseph

MIR-7 Advanced Methods in Robotics

Module code	MIR-7
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR2101 Advanced Methods in Robotics
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

An "Advanced Methods in Robotics" course typically delves into more advanced concepts and techniques in the field of robotics, assuming a foundation in robotics fundamentals. The course covers a wide range of advanced topics in robotics, focusing on practical applications and emerging trends. It's designed to provide students with a deep understanding of advanced methods and the ability to apply them to real-world robotics problems.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Gain a deep understanding of advanced robotics principles, technologies, and methodologies.
- Develop skills in using advanced sensors and perception techniques, such as Lidar, depth cameras, and Visual SLAM, to enhance robotic perception.
- Master advanced motion planning and control algorithms, including reinforcement learning and real-time reactive control.
- Aquire proficiency in using machine learning for robotics applications, from supervised and unsupervised learning to reinforcement learning and transfer learning.
- Develop the ability to implement Simultaneous Localization and Mapping (SLAM) techniques for robot localization and environment mapping.

Methodological competence:

- Enhance problem-solving skills, particularly in addressing complex challenges in robotics and applying appropriate methodologies.
- Gain experience in experimental design, data collection, and analysis for robotics research and development.
- Acquire project management skills for planning, executing, and delivering robotics projects

Personal competence:

- Strengthen self-motivation for continuous learning, experimentation, and exploration of advanced robotics concepts.
- Improve adaptability in keeping pace with rapidly evolving robotics technologies and methodologies.

Social competence:

- Enhance the ability to work effectively in multidisciplinary teams on complex robotics projects.
- Build leadership skills and the capacity to mentor and guide peers in advanced robotics concepts and projects .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of autonomous robotics and algorithms for autonomous systems in different systems and applications. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

The "Advanced methods in robotics" course is designed to provide students with an in-depth exploration of advanced concepts, methodologies, and technologies in the field of robotics. Building upon fundamental robotics knowledge, this course delves into cutting-edge advancements, including advanced sensors, perception, planning and control, machine learning for robotics, human-robot interaction, and practical applications in various domains. Through a combination of theoretical learning, hands- on projects, and research opportunities, students will develop the skills and expertise required to tackle complex robotics challenges and contribute to the advancement of the field.This results in several relevant subject areas, such as:

- Advanced Sensors and Perception
- Robot Planning and Control
- Soft robotics
- Simultaneous Localization and Mapping
- Machine Learning for Robotics
- Autonomous self-driving vehicles
- Swarm robotics

Furthermore, this module addresses the application of autonomous systems relevant to the industry and delves further into the content of mobile and collaborative robotics.

Relevant subject areas:

- Advanced manipulation and grasping
- Human-Robot Interaction

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Probabilistic Robotics" by Sebastian Thrun, Wolfram Burgard, and Dieter Fox

[2]. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto

[3]. "Introduction to Autonomous Robots" by Nikolaus Correll, Bradley Hayes, et al.

[4]. "Soft Robotics: A Reference Manual" by Auke Ijspeert, et al.

[5]. "Human-Robot Interaction: An Introduction" by Kerstin Dautenhahn, et al.

[6]. "SLAM: Simultaneous Localization and Mapping for Robots" by Giorgio Grisetti, et al.

[7]. "Robotics: Science and Systems" (Proceedings of the annual RSS conference)

MIR-8 Image Processing and Computer Vision

Module code	MIR-8
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 2102 Image Processing and Computer Vision
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The "Image Processing and Computer Vision" course provides students with a comprehensive understanding of the principles, algorithms, and applications of image processing and computer vision. Students will learn to manipulate, enhance, and analyze digital images and develop the skills to build computer vision systems. The course covers both theoretical foundations and practical applications, enabling students to apply image processing and computer vision techniques to real-world problems. By the end of the "Image Processing and Computer Vision" course, students will have developed a comprehensive skill set that includes advanced technology expertise, strong problem-solving abilities, and effective interpersonal and communication skills. These competences will prepare them for careers in fields such as image analysis, computer vision, machine learning, and artificial intelligence.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Develop a deep understanding of image processing techniques, including filtering, enhancement, and segmentation.
- Gain skills in computer vision, covering object optical flow, and 3D reconstruction.
- Acquire knowledge of deep learning models, especially convolutional neural networks (CNNs), for image classification, object detection, and semantic segmentation.
- Apply image processing and computer vision techniques to solve real-world problems, such as object detection, tracking, and augmented reality.
- Explore emerging trends in computer vision, enabling students to stay current with the latest advancements and contribute to the field.

Methodological competence:

- Develop skills in designing experiments and evaluating the performance of image processing and computer vision algorithms.
- Acquire project management skills, from conceptualization and design to implementation and testing of computer vision applications.
- Enhance problem-solving skills, particularly in diagnosing and addressing issues in image analysis and computer vision.
- Understand the importance of simulation and testing in the development and validation of computer vision systems.

Personal competence:

- Foster critical thinking and analytical skills to evaluate and improve image processing and computer vision solutions.
- Cultivate innovation and creativity in designing novel computer vision applications and addressing complex challenges.
- Improve adaptability to keep up with rapidly evolving technologies and methodologies in image processing and computer vision.

Social competence:

- Enhance the ability to work effectively in multidisciplinary teams on complex computer vision projects .
- Develop conflict resolution skills, especially in situations with differing project goals and opinions within the team .
- Improve the ability to communicate complex technical ideas to both technical and non-technical stakeholders .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of computer vision systems in different systems and applications. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

Image processing and computer vision are two closely related fields in computer science and engineering that deal with the analysis, understanding, and manipulation of visual information from images and videos.

Topics:

- Introduction to Image Processing
- Image Filtering and Enhancement
- Image Segmentation and Object Recognition
- Feature Extraction and Descriptors
- Computer Vision Fundamentals
- Deep Learning for Computer Vision
- Image-based rendering and augmented reality.
- Visual SLAM (Simultaneous Localization and Mapping).

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application.
- i-Learn (online learning platform).

Recommended Literature

[1]. "Digital Image Processing" by Rafael C. Gonzalez and Richard E. Woods

[2]. "Computer Vision: Algorithms and Applications" by Richard Szeliski

[3]. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

[4]. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron

[5]. "Learning OpenCV 4 Computer Vision with Python" by Joseph Howse, Prateek Joshi, and Vishwesh Ravi Shrimali

MIR-9 Robot Modeling and Simulation

Module code	MIR-9
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 2103 Robot Modeling and Simulation
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The "Robot Modeling and Simulation" course focuses on advanced software aspects of robot modeling and simulation. This course explores advanced software tools, libraries, and platforms used for modeling and simulating robotic systems, with a particular focus on software aspects. Students will delve into topics such as dynamics, sensor simulation, control algorithms, high-level simulation environments, multibody dynamics, soft robots, parallel and redundant manipulators, hybrid systems, advanced sensor simulation, and virtual reality (VR) applications in robotics simulation. The course includes research or project work that emphasizes advanced software applications in robot simulation.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Develop an advanced level of proficiency in using software tools, libraries, and platforms for robot modeling and simulation .
- Gain expertise in modeling multibody dynamics and constraint-based modeling, enabling accurate simulation of complex robotic systems.
- Specialized knowledge and skills in simulating soft robots and deformable bodies, which are increasingly important in robotics applications.
- Master the simulation of complex robot manipulators, including parallel and redundant systems, and apply advanced control algorithms.
- Develop the ability to model and simulate hybrid systems and engage in co-simulation of diverse subsystems within robotics applications.

Methodological competence:

- Develop advanced skills in designing and analyzing complex robotic simulations, including performance evaluation and optimization.
- Learn advanced methods for experimentation and testing in simulated environments, with a focus on real-time control and performance assessment.
- Enhance problem-solving skills, particularly when addressing challenges related to multibody dynamics, soft robotics, and parallel manipulators.

Personal competence :

- Cultivate advanced critical thinking and creative problem-solving skills when faced with complex issues in robot modeling and simulation.
- Develop the ability to adapt to rapidly evolving software and technology, staying current with the latest advancements in robotics simulation.
- Strengthen self-motivation and initiative, especially when undertaking advanced research or project work in a specialized area.

Social competence:

- Collaboration skills when working with multidisciplinary teams on complex robotics projects, leveraging advanced software applications .
- Improve advanced communication skills to convey complex technical ideas to both technical and non-technical stakeholders .
- Build leadership skills and the capacity to mentor and guide peers in advanced software applications within the context of robotics simulation .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of tools and instrumentation for robot modeling and simulation. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

By the end of the course, students will have developed a comprehensive skill set that includes advanced software proficiency, in-depth knowledge of advanced topics in robotics simulation, and the ability to engage in cutting-edge research or advanced projects in the field. These competences prepare them for roles in software development, research, and innovation within the domain of robot modeling and simulation.

Topics:

- Advanced Robot Kinematics and Dynamics with Software.
- High-Level Simulation Platforms and Software.
- Advanced Software for Robot Simulation.
- Virtual Reality (VR) and Robotics Simulation.
- Advanced Sensing and Perception.
- Advanced Sensor Simulation.
- Software-based optimization for motion planning and control.
- Advanced Robot Manipulation and Grasping Software.

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Parallel Robots" by J. M. Herve

[2]. "Modeling and Control of Robot Manipulators" by Lorenzo Sciavicco and Bruno Siciliano

[3]. "Hybrid Systems: Computation and Control" by Rajeev Alur and George J. Pappas

[4]. "Virtual Reality and Augmented Reality: Myths and Realities" by Philippe Fuchs, Guillaume Moreau, and Pascal Guitton

MIR-10 Industrial Robotics and Automation

Module code	MIR-10
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 2104 Industrial Robotics and Automation
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The "Industrial Robotics and Automation" course provides an in-depth exploration of the principles, technologies, and applications of industrial automation and robotics systems. Students will learn about the design, programming, and operation of industrial robots, as well as the integration of automation solutions in manufacturing and industrial processes.Upon completion of this module, the student has achieved the following learning objectives:

- Develop a strong understanding of industrial robotics and automation systems.
- Gain proficiency in the operation and programming of industrial robots.
- Learn about automation technologies, including PLCs and SCADA systems.

- Apply knowledge to the design and optimization of automated manufacturing processes.

Professional competence:

- Develop a deep understanding of industrial robotics and automation systems, including their design, operation, and applications in manufacturing.
- Gain practical skills in programming and controlling industrial robots, covering topics such as kinematics, dynamics, and vision systems.
- Acquire proficiency in Programmable Logic Controllers (PLCs) and Supervisory Control and Data Acquisition (SCADA) systems, including programming and integration.
- Learn to design and implement automation solutions for industrial processes, considering factors like safety, efficiency, and cost-effectiveness.

Methodological competence:

- Develop the ability to analyze and solve complex problems in industrial automation and robotics, both theoretically and practically.
- Gain practical experience in programming, configuring, and operating industrial robots and automation systems through labs and projects.
- Learn to design experiments and analyze data to optimize automation solutions and manufacturing processes.

Personal competence:

- Foster critical thinking skills to evaluate and improve automation and robotics solutions in a constantly evolving industry.
- Develop adaptability to keep pace with rapidly changing automation technologies and methodologies.
- Cultivate self-motivation for continuous learning and problem-solving in the field of industrial robotics and automation.

Social competence:

- Collaboration skills when working with multidisciplinary teams on complex robotics projects, leveraging advanced software applications .
- Improve advanced communication skills to convey complex technical ideas to both technical and non-technical stakeholders .
- Build leadership skills and the capacity to mentor and guide peers in advanced software applications within the context of robotics simulation .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of automation technologies, including PLCs and SCADA systems. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelors degree in mechatronics or a closely related field.

Learning Content

This "Industrial Robotics and Automation" course aims to equip students with the knowledge and skills required for careers in industrial automation, manufacturing, and robotics. It covers fundamental principles, hands-on experience, and emerging trends in the field, making it a valuable course for those looking to enter the industrial automation industry **.**

Topics:

- Industrial Robot Fundamentals
- Industrial Automation Technologies
- Automation Sensors and Actuators
- Automation System Integration
- Industrial Robotics in Practice
- Industry 4.0 and smart manufacturing .

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Industrial Automation and Robotics: An Introduction" by A. K. Gupta

[2]. "Industrial Robotics: Technology, Programming, and Applications" by Mikell P. Groover and Mitchell Weiss

[3]. "Introduction to Autonomous Robots" by Nikolaus Correll, Bradley Hayes, et al. [4]. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar

[5]. "PLC Programming Using RSLogix 5000: Basic Concepts of Ladder Logic Programming!" by Gary Dunning.

MIR-11 Case Study "Robotic Systems"

Module code	MIR-11
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 2106 Case Study "Robotic Systems"
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The Case Study **"Robotic systems"** addresses current questions in this area and gives students the opportunity to engage with these topics independently and creatively. Furthermore, students are given the opportunity to deal with Robotic

systems independently and creatively. Upon completion of this module, depending on a more theoretical or more practical focus, students will be able to identify limitations and opportunities algorithms and application of robotic systems their specific field of application.

This module focuses on understanding real-world applications of robotics through in- depth analysis of specific projects and use cases. The course uses case studies as the primary teaching method, allowing students to explore the challenges, solutions, and outcomes of various robotic systems in different industries.

Professional competence :

- Develop a deep understanding of robotic systems, including their components, control algorithms, and programming.
- Gain skills in selecting and configuring robotic actuators, sensors, and control systems.
- Acquire proficiency in programming robots, including the use of robotic software platforms like ROS (Robot Operating System).
- Understand the kinematics of robotic systems and how to plan and control their movements.
- Learn to use computer vision and perception techniques for object recognition and tracking in robotic applications.

Methodological competence :

- Develop skills in designing experiments to test and evaluate robotic systems, including data collection and analysis.
- Gain proficiency in managing robotic projects, from conceptualization and design to implementation and testing.
- Enhance problem-solving skills, particularly in diagnosing and addressing issues in robotic systems.
- Understand the importance of simulation and testing in the development and validation of robotic systems.
- Learn to document project work and communicate technical concepts effectively to peers and stakeholders.

Personal competence :

- Foster critical thinking and analytical skills to evaluate and improve robotic systems.
- Cultivate innovation and creativity in designing novel robotic solutions and solving real-world problems.
- Improve adaptability to keep up with evolving robotics technologies and methodologies.

Social competence :

- Teamwork and Collaboration: Enhance the ability to work effectively in multidisciplinary teams on complex robotics projects.
- Conflict Resolution: Develop conflict resolution skills, especially in situations with differing project goals and opinions within the team.
- Empathy and Ethical Responsibility: Foster empathy and ethical responsibility in considering the social and ethical implications of advanced robotics technologies.
- Communication Skills: Improve the ability to communicate complex technical ideas to both technical and non-technical stakeholders .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and the transfer capability to gain a deeper understanding of robotic systems design, implementation and related software principles and the capability to apply and to evaluate autonomous systems in and for a specific area of application. This creates interfaces to courses of study such as mechanical engineering, mechatronics, electrical engineering

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

On the basis of an application example selected, students need to conduct literature research and, if applicable, independently work on the topic with small sub- tasks. Within an introductory part, the over-arching topic will be explained, and sub- tasks defined.

Example: Autonomous Driving

- Features of necessary networked systems
- Aspects of functional safety for autonomous vehicles
- Sensor/actuator technology for the vehicle control system
- Autonomous driving and mobility concepts
- Development and implementation of algorithms in autonomous systems
- Construction, implementation and test of autonomous systems

The topics of the case studies can vary each semester.

Teaching Methods

- Guided work on seminar topics in working groups. Accompanying events / presentations by external speakers depending on the selected topic area
- i-learn (Online learning platform)
- Literature research

Remarks

The case studies are examined as so-called Prüfungsstudienarbeit and are therefore not a classic examination.

The theoretical knowledge acquired by the students is specifically applied in practice in the case study topics so that students analyse problems independently and apply proposed solutions. This intensifies the transfer of knowledge into practice and the targeted deepening of the acquired technical and methodological competences by recognising connections and evaluating them.

Recommended Literature

[1]. "Robotics: Modelling, Planning and Control" by Bruno Siciliano, Lorenzo Sciavicco, et al.

[2]. "Mobile Robotics: A Practical Introduction" by Ulrich Nehmzow

[3]. "Probabilistic Robotics" by Sebastian Thrun, Wolfram Burgard, and Dieter Fox [4]. "Robotics: Control, Sensing, Vision, and Intelligence" by C.S.G. Lee and K. S. Fu

MIR-12 Intelligent Multi-Agent Systems

Module code	MIR-12
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 2106 Intelligent Multi-Agent Systems
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The "Intelligent Multi-Agent Systems" course provides an in-depth exploration of the principles, algorithms, and applications of multi-agent systems. Multi-agent systems involve multiple agents or entities that interact to achieve a common goal. These systems have applications in various domains, including robotics, distributed computing, autonomous vehicles, and more. Students will learn about the design of intelligent agents, negotiation, cooperation, coordination, and decision-making in multi-agent environments. The course will cover both theoretical foundations and practical applications, enabling students to design and implement intelligent multi- agent systems.

Upon completion of this module, the student has achieved the following learning objectives:

Professional competence:

- Develop a deep understanding of multi-agent systems, their principles, and their applications.
- Gain skills in designing intelligent agents capable of autonomous decision-making and communication.
- Learn to design and implement communication and negotiation protocols for effective agent interactions.
- Understand the principles of cooperation and coordination among multiple agents, including task allocation and planning.
- Explore advanced topics such as coalition formation, game theory, swarm intelligence, and collective behavior in multi-agent systems.

Methodological competence:

- Develop skills in designing experiments and simulations to evaluate the performance of multi-agent systems.
- Acquire project management skills for developing multi-agent systems, including requirements analysis, design, and testing.
- Enhance problem-solving skills, particularly in diagnosing and addressing issues in multi-agent systems.
- Understand the importance of simulation and testing in the development and validation of multi-agent systems.

Personal competence:

- Foster critical thinking and analytical skills to evaluate and improve multi-agent systems.
- Cultivate innovation and creativity in designing intelligent multi-agent solutions and addressing complex challenges.
- Improve adaptability to keep pace with evolving technologies and methodologies in multi-agent systems.

Social competence:

- Improve the ability to communicate complex technical ideas to both technical and non-technical stakeholders.
- Build leadership skills and the capacity to mentor and guide peers in advanced robotics concepts and projects.
- Gain insights into the challenges and opportunities presented by global collaboration in the development and application of intelligent multi-agent systems .

Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of multi-agent systems and algorithms in different systems and applications. Interfaces to mechatronics, electrical engineering and computer engineering.

Entrance Requirements

Bachelor degree in mechatronics or a closely related field.

Learning Content

This "Intelligent Multi-Agent Systems" course equips students with a solid foundation in multi-agent systems theory and practical development. By the end of the course, students will have the knowledge and skills to design, implement, and analyze intelligent multi-agent systems for various applications, making them valuable contributors in the fields of robotics, distributed computing, and more.

Topics:

- Overview of multi-agent systems.
- Historical perspective and milestones in multi-agent systems .
- Intelligent Agents.
- Agent architectures and design principles .
- Autonomous agents, communication, and collaboration .
- Communication and Coordination.
- Autonomous agents, communication, and collaboration .
- Coordination mechanisms: centralized, decentralized, and distributed .
- Negotiation protocols and strategies .
- Cooperation and Collaboration.
- Multi-agent planning and task allocation .
- Multi-agent learning and knowledge sharing .
- Swarm intelligence and collective behavior .
- Simulation and testing of multi-agent systems .

Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- i-Learn (online learning platform)

Recommended Literature

[1]. "Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations" by Yoav Shoham and Kevin Leyton-Brown

[2]. "Introduction to Multiagent Systems" by Michael Wooldridge

[3]. "Multiagent Systems: A Modern Approach to Distributed Artificial Intelligence" by Gerhard Weiss

[4]. "Swarm Intelligence" by Russell C. Eberhart and Yuhui Shi

[5]. "Reinforcement Learning: An Introduction" by Richard S. Sutton and Andrew G. Barto

[6]. "Agent-Based and Individual-Based Modeling: A Practical Introduction" by Steven L. Railsback and Volker Grimm

MIR-13 Subject-Related Elective Course (FWP)

Module code	MIR-13
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR-13 Subject-Related Elective Course (FWP)
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weighting of the grade	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Students can choose from a range of FWP subjects as part of the compulsory elective subject module.

Courses from a subject catalogue of related studies are offered at the DIT and, if applicable, the Virtual University of Bavaria (VHB), e.g.

- Computer Networking and Secure Network Management Interactive Online (CNSM)

Further courses deepen scientific topics in the field of artificial intelligence in production and logistics.

The offer is reviewed every semester and updated if necessary.

After completing the FWP module, the students have achieved the learning goals defined in the sub-module.

In the FWP module, the following competences are to be taught:

Professional competence:

The competences result from the chosen FWP subject.

Methodological competence:

The competences result from the chosen FWP subject.

Personal competence:

The competences result from the chosen FWP subject.

Social competence:

The competences result from the chosen FWP subject.

Applicability in this and other Programs

All Master's programmes in which technical knowledge is required to solve complex problems.

Entrance Requirements

Bachelor`s degree in mechatronics or a closely related field

Learning Content

The contents result from the respective FWP subject.

Teaching Methods

The didactic methods result from the respective FWP subject.

Remarks

The FWP range of subjects includes courses with different ECTS values. Students are advised to take courses with at least 5 ECTS values.

The type of examination conducted for FWP courses is subject to the currently valid study regulations.

Recommended Literature

The literature result from the respective FWP subject.

MIR-14 Master Module

Module code	MIR-14
Module coordination	Prof. Dr. Dmitrii Dobriborsci
Course number and name	MIR 3101 Master Thesis MIR 3102 Master Colloquium
Lecturer	Prof. Dr. Dmitrii Dobriborsci
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 30 hours self-study: 720 hours Total: 750 hours
Type of Examination	colloquium, master thesis
Weighting of the grade	25 out of 90 ECTS
Language of Instruction	English

Module Objective

The master's programme " **Intelligent Robotics"** is concluded with a master thesis. Students are expected to prove that they can independently and successfully complete a certain task within a given period of time and that they can apply scientifically-founded theoretical and practical knowledge to solve a problem. After successful completion of the master thesis, students are able to work independently on complex scientific/technical tasks. They solve problems using digital methods as well as tools and find answers to current questions in the field of robotics.

The teaching content taught during the course of studies is applied in the form of a scientific paper. The problem is to be independently analysed, structured and processed within a given time frame. This trains the ability to independently work on technical problems of a larger related topic and to process the results in scientific form. The aim is, among other things, to deepen and apply the ability to document the results transparently.

In addition to the Master's thesis (20 ECTS), the Master's seminar (5 ECTS) is also part of this module. The master's seminar consists of two parts that must be passed to successfully complete the module. To prepare for the master's thesis, participation in the seminar series "Career Start into German Technology Companies" is mandatory. The seminars / workshops are offered as block events during the first two semesters of study. The events cover a variety of topics that are of great importance for the preparation of the Master's thesis. In addition to scientific working methods, students are also introduced to application processes and the general conditions of the German labour market and its entry after graduation. The second part of the Master's seminar consists of the colloquium. After submitting the Master's thesis, it is presented in a presentation of about 15 minutes and then defended. The colloquium is assessed with 5 ECTS.

Professional competence

Students are enabled to familiarise themselves with technical tasks, to analyse problems independently and to solve them.

After completing the module, students are able to work on a problem from the broad field of artificial intelligence for smart sensor and actuator technology in a scientifically sound manner.

Methodological c ompetence

The ability to independently work on and solve a comprehensive problem from the engineering sciences on a scientific basis is the overriding goal of methodological competence.

Personal competence

Independent, autonomous and self-disciplinary scientific, methodical processing of a practice-relevant, delimitable (sub-)project in a study programme-related environment as well as written, independent documentation in the form of a scientific paper and require personal skills.

Social competence

The students improve their social and interface competence through intensive communication with the supervisors at the Deggendorf Institute of Technology and in the cooperating industrial company.

Applicability in this and other Programs

The Master's programme " **Intelligent Robotics** " enables students to work scientifically. The Master's degree entitles the holder to a subsequent doctorate.

Entrance Requirements

The registration for the master thesis requires that at least 40 ECTS credits have been achieved (cf. study and examination regulations (SPO).

Learning Content

The topic of the master thesis will be set by a professor of the participating universities or by a cooperating company. In addition, the students are entitled to propose their own topics. A DIT professor is responsible for supervision and content support.

The master thesis includes:

- Presentation of the state-of-the art in science and technology of the topic being worked on
- Description of the methodology and the course of the own theoretical and experimental procedure including concept development
- Decision-making regarding the most favourable problem solution
- The integration of the own work into the work of the supervising institutes/ faculties and possible industry partners.
- Report on own publications
- Report on the applications/possible applications for funding within the scope of the topic
- Creation of test setups and programs
- Execution of measurements and test runs including their evaluation
- Scientific documentation of the technical results achieved and their evaluation
- Study of literature

By writing a master thesis, students should demonstrate their ability to apply the knowledge and skills acquired during their studies to an independent scientific thesis. The master thesis is followed by a colloquium as an oral examination. The students present their master thesis and defend it.

Teaching Methods

Guidance to independent work according to scientific methods by the respective supervisor.

Seminars, workshops, colloquium

Remarks

The subject content of the master thesis can be chosen freely and individually by students. The topic must be recognised by the supervising professor. Furthermore, it is possible to work on a topic in cooperation with a company and to work on a research topic at the faculty.

Recommended Literature

Literature selected by the student for the specific subject area. Support for scientific work:

Eco, Umberto: How to write a scientific thesis; 13th edition; UTB Verlag; Vienna; 2010.

Scheld, Guido: Instructions for the preparation of internship, seminar and diploma theses as well as bachelor and master theses; 7th edition; Fachbibliothek Verlag; Büren; 2008.

Rossig, Wolfram; Prätsch, Joachim: Scientific works: Guidelines for term papers, bachelor's and master's theses, diploma and master's theses, dissertations; 7th edition; team printing; Weyhe; 2008.

Standop, Ewald; Meyer, Matthias: The form of scientific work; 18th edition; Quelle & Meyer; Wiebelsheim; 2008.