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Faculty of Engineering, Computer Science and Psychology

Module Handbook

Master's degree program M.Sc. Artificial Intelligence for Connected Industries

Winter semester 2025/2026

Based on Rev. **336**. Last changed at **20.02.2025**, **01:55** from **smoser**. Generated at **20.02.2025**, **02:56**.

Table of contents

1 Artificial Intelligence and Machine Learning for Connected Systems

Token / Number:	AIML
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Pedro B. Velloso
Training staff:	Pedro B. Velloso (CNAM) Lehel Csato (UBB) Yannick Esteve (AU) Vlad Taran (NTUU) Eduard Garcia (UPC) David Remondo (UPC)
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Module,
Requirements (contentual):	Calculus, Algebra, basic concepts of statistics and probability. Prior knowledge on Python is strongly recommended
Learning objectives:	The main goal of this course is to cover the basic concepts related to machine learning projects and present the main ML models and algorithms and how to apply them to connected systems.
Content:	The course alternates between theoretical lectures and lab sessions. The main idea consists of presenting the theoretical background of a specific subject, followed by a lab session in which students will learn more details about each model and algorithm with practical examples using the most popular tools and libraries available. The course includes hands-on lab sessions with practical assignments, some of which are evaluated. The course is connected-systems oriented, which means that, in addition to the most popular datasets, like MNIST and California houses, students will also see other examples of network-related datasets. **Topics:** - Introduction to AIML. - Practical skills and Linear Regression. Lab: end-to-end work, exploratory data analysis. - Supervised Learning and Classification (Decision Trees and Random Forest, Bayesian Detection, Non-Parametric Classifiers) Lab: Classification, Linear and Quadratic Discriminants, K-nearest neighbors (KNN). - Dimensionality Reduction Lab: Principal Component Analysis (PCA), Multiple Discriminant Analysis (MDA) - Unsupervised Learning Lab: Clustering - Artificial Neural Networks, Deep Neural Networks (DNN) Lab: Neural Networks, Multi-Layer Perceptron (MLP) - Training enhancement techniques (e.g. Ensembles, in DNN)

Content (continued):	**Complementary content:** - Basics on Reinforcement Learning Lab: Basics of Reinforcement Learning - Data processing tools (e.g. TensorFlow, Scikit learning) Lab: management of time-series in Recurrent Neural Networks (RNN) Lab tools - Language: Python - Frameworks and libraries: Numpy, Pandas, Matplotlib, Scikit-Learn, Tensor Flow, Keras, Google Colab, LaTeX, and Overleaf Datasets - Iris - Ridership: Bus and Rail rides in Chicago - CTU-13: 13 attack scenarios from botnets - 5G-Traffic: Traffic load in different cities in France - LiveStreaming: Live streaming data of user's connections (World Cup matches).
Literature:	- James, G., Witten, D., Hastie, T., Tibshirani, R. "An Introduction to Statistical Learning", 2nd edition, 2021 - Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow", 2nd Edition, O'Reilly Media, 2019 - Tom Mitchell, "Machine Learning", McGraw-Hill Science, 1997 - R. O. Duda, P. E. Hart, D. G. Stork, Pattern Classification, Ed. Wiley Interscience, 2002. - Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

2 Master's Thesis

Token / Number:	MA
Credits:	30 ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Prof. Dr. Birte Glimm
Training staff:	Master's thesis supervisor
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Module, Master's thesis
Requirements (contentual):	It is desirable to have taken basic modules in the field of the master's thesis.
Learning objectives:	Students graduating from the master's degree are expected to integrate the following sectors: - Smart factories, Industry 4.0. - Datacenter and cloud providers - IoT software editors - Embedded systems manufacturer - Internet and mobile application editors - Telecommunication network operators. - Smart-city and smart-grid network providers - Artificial intelligence start-ups - Security and defense
Content:	This unit is dedicated to the development of the master's specialisation dissertation on the definition, evaluation, modelling and/or experimentation of new algorithms, protocols, network architectures and IoT.
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Selection of an appropriate topic **Sum:** 900 h
Grading procedure:	Evaluation of written dissertation report and final defence.
Requirements (formal):	not specified

3 Wireless Sensor Networks

Token / Number:	WSN
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Summer Semester / 1 Semester
Module authority:	Prof. Dr. rer. nat. Frank Kargl
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Systems and Networks
Requirements (contentual):	Fundamentals in computer networks, operating systems, and computer architectures. Programming skills in C or Python.
Learning objectives:	Students can explain the essential requirements and unique challenges of wireless ad-hoc networking; they can identify differences to classical wired networks and explain them. Given specific application requirements, students are able to design simple examples of wireless sensor network systems and construct and evaluate these systems. In particular, students are able to select existing routing and data dissemination strategies and adapt or extend them to suit specific scenarios. They can describe state of the art of wireless sensor network research and seminal research works. Using the acquired methods, students independently analyze new literature in sub-domains that were not covered in the lectures. They explain fundamental concepts of security and privacy protection in WSNs, select appropriate protection mechanisms, and integrate them in system architectures.
Content:	- Introduction to Wireless Sensor Networks (WSN): requirements, applications, and examples - Hardware and software platforms for WSNs - Link-layer technologies for WSN communication - Networking protocols and data dissemination strategies - WSN security and privacy - Simulative and experimental evaluation - Related domains (e.g., vehicular ad-hoc networks, delay-tolerant networks)
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

Based on Rev. **334**. Last changed at **20.02.2025**, **01:43** from **smoser**.

4 Design Methodology of Embedded Systems

Token / Number:	EES
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Prof. Dr.-Ing. Frank Slomka
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Systems and Networks
Requirements (contentual):	Fundamentals of computer architecture or embedded systems architecture
Learning objectives:	In taking part in the module "Design Methodology of Embedded Systems" the students learn how to describe and sketch the model-based design of embedded systems. They will be able to name and distinguish different analytic processes for the assessment of embedded systems. From a set of different methods and algorithms for the analysis of real-time operation, they will learn how to pick a suitable method in order to solve a given problem. The participants will be enabled to build new methods and algorithms and to prove their correctness. The students will be able to identify the complexity of algorithms and to develop approximations. Moreover, they will be able to assess various designs of embedded systems and to compare them.
Content:	Even if you cannot see them – embedded systems are everywhere. Very often, the only time that we take notice of them is when they no longer function properly: All of a sudden, the expensive new car refuses to go any further. Doors in the shopping mall do not open or close anymore at closing time. The barrier in the parking garage remains closed. The smart phone cannot login at the network. Not only can certain bugs take away comfortable functions, incorrectly designed systems can be extremely dangerous and become very expensive. For example, there were certain incidents when rockets that had expensive satellites on board had to be blown up because they lost their intended trajectories and became a threat. One of the most cost-intensive mistakes throughout the history of embedded systems was the explosion of an "Ariane" rocket in 1996. The damage reached 370 Million US$ and was caused by an overflow of a register which on the other hand was the outcome of the fact that Ariane 5 accelerated quicker than the predecessor Ariane 4. Embedded Systems became so complex during the course of the last decades that methods of computer-assisted design have to be applied. This module deals with the building of models and the analysis of embedded systems, focusing on the design of a uniform model for event-driven real-time systems.

Content (continued):	The course focuses mainly on: - Model-based design of embedded systems - Time and real-time systems - Modeling of embedded systems: event models and graphs - Intrinsic analysis of real-time systems - Extrinsic analysis of real-time systems - Complexity and approximation of the extrinsic analysis - Optimization and Design Space Exploration
Literature:	- Jürgen Teich: Digitale Hardware-/Software Systeme, Springer 1996 - Peter Liggesmeyer und Dieter Rombach: Software Engineering eingebetteter Systeme, Spektrum Akademischer Verlag 2005 - Jean J. Labrosse: Embedded Systems Building Blocks, CMP 2000 - Peter Marwedel: Eingebette Systeme, Springer 2007 - Zbigniew Michalewicz und David B. Fogel: Modern Heuristics, Springer, 2000
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

5 Modules from “Systems and Networks” from partner universities

Token / Number:	not specified
Credits:	depends on the modules you choose ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Partner Universities
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Systems and Networks
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Recommended modules: - Parallel and Distributed Systems - Wireless and Mobile Networks - Network Virtualization and Automation
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

6 Signals and Systems

Token / Number:	SaS
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Dr. Werner Teich
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	Advanced Mathematics
Learning objectives:	The concepts of signals and systems are powerful tools for any engineer dealing with information bearing, measurable physical quantities. Areas of applications include, among others, communications engineering, signal processing, control engineering, and systems engineering. The students will be able to classify, interpret, and compare signals and systems with respect to their characteristic properties. They can explain and apply analytical and numerical methods to analyze and synthesize signals and systems in time and frequency domain. Suitable signal transformations can be chosen and calculated with the help of transformation tables. The students are able to recognize stochastic signals and analyze them based on their characteristic properties. They can calculate and interpret the influence of linear time-invariant systems on stochastic signals.
Content:	- Basic properties of discrete-time and continuous-time systems - Z-transform - Basic properties of discrete-time and continuous-time systems - Linear time-invariant systems, convolution integral - Fourier transform, discrete Fourier transform, Fourier series - Sampling theorem - Probability theory, random variables, and stochastic processes - Stochastic signals and linear time-invariant systems
Literature:	- Alan V. Oppenheim and Alan S. Willsky: Signals and Systems, Prentice Hall 1996 - Mrinal Mandal and Amir Asif: Continuous and Discrete Time Signals and Systems, Cambridge University Press, 2007 - Athanasios Papoulis and S. Unnikrishna Pillai: Probability, Random Variables, and Stochastic Processes, McGraw-Hill, 2002 - Thomas Frey und Martin Bossert: Signal- und Systemtheorie, B.G. Teubner Verlag, 2004 - Jens Ohm und Hans Dieter Lüke: Signalübertragung, Springer Verlag 2010
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h

Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

7 Control System Theory and Control Engineering

Token / Number:	STCE
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Dr.-Ing. Sönke Rhein
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	- Fundamentals of higher mathematics, especially linear algebra - Fundamentals of signals and systems - Basic design methods for LTI systems in frequency domain - Description of linear, time-invariant systems in time and frequency domain, Laplace transform, analysis of LTI systems (Bode and Nyquist plots)
Learning objectives:	To an increasing degreee, requirements on safety, sustainability and economic feasibility of technical products and production plants call for modern approaches of control-theory-based methods. Especially in the environment of control theory, simple and heuristically designed controllers have been reaching their limits. Systematic design of model-based controllers in time domain allows considering of non-linearities and has the potential to achieve significantly improved controller results. Students are able to describe the necessary mathematics and system-theory basics. They are capable of applying the methods of model-based control theory to linear and non-linear systems. They are able to describe and analyze time-continuous systems in time domain. They are able to categorize systems according to system-theoretic properties. Further, they have the ability to apply formal methods in order to design controllers in time domain. They are also able to apply methods for designing controllers for non-linear systems and are capable of managing its operation.
Content:	- Linear and non-linear time-continuous systems in state space - Linearization and general solution of linear differential equations of states - Structural properties of LTI systems in state space (stability, controllability, observability - Design of state controllers and state observers for linear systems - Analysis of non-linear systems (Lyapunov-stability) - Control and feedback control of non-linear systems
Literature:	- J. Lunze: Regelungstechnik 1: Systemtheoretische Grundlagen, Analyse und Entwurf einschleifiger Regelungen. 4 Auflage Springer-Verlag, Berlin, 2006 - J. Lunze: Regelungstechnik 2: Mehrgrößensysteme, Digitale Regelung. Springer-Verlag, Berlin, 2004 - T. Kailath: Linear Systems. Prentice Hall, Upper Saddle River, 1980 - W.J. Rugh: Linear System Theory, Prentice Hall, 1996 - H.K. Khalil. Nonlinear Systems. Prentice Hall, Upper Saddle River, 2002 - S. Sastry. Nonlinear Systems. Springer, New York, 1999 - A. Isidori. Nonlinear Control Systems. Springer, Berlin, 3rd edition, 1995
Basis for:	Module Modeling and identification of dynamic systems, master's thesis in the domain of control and automatization technology

Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

8 Modeling and Identification of Dynamic Systems

Token / Number:	MIDS
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Dr.-Ing. Sönke Rhein
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	- Fundamentals of higher mathematics, especially linear algebra - Fundamentals of signals and systems - Basics of control theory in frequency and time domain
Learning objectives:	Appropriate descriptions of systems are the base of many methods in control theory and are required for model-based monitoring. Model-based techniques open extensive paths to optimize existing control systems in industrial applications. The main requirement are proper mathematical models which on the one hand represent all important dynamic effects as precisely as possible, and stay feasible regarding computational complexity on the other hand. It is further important to be able to determine parameters which are not observable. Students are able to describe and apply methods of mathematical modeling of technical processes based on physical principles. They are further able to describe technical systems of various physical domains using mathematical formalisms. They are especially able to derive suitable models for controller design and to parameterize the models with identification procedures, e.g. with using black box models. Students are capable of designing optimal state estimaters and state controllers. Thereby, they can apply according methods of identification, estimation, and control.
Content:	- Modeling mechanical, electrical, and hydraulic systems - Parameter-based and non-parameter-based identification approaches - Optimal estimation procedures and filter (e.g. Kalman filter)
Literature:	- P.E. Wellstead: Physical Systems Modelling, Academic Press, 1979 - R. Isermann: Mechatronische Syteme: Grundlagen, Springer, 2002 - R. Isermann: Identifikation dynamischer Systeme 1 und 2, Springer, 1992 - D.G. Luenberger: Optimization by Vector Space Methods, John Wiley & Sons, 1969 - A. Gelb: Applied Optimal Estimation, M.I.T. Press, 1974 - A.E. Bryson, Y.-C. Ho: Applied Optimal Control, Hemisphere Publishing Corporation, 1975
Basis for:	Master's thesis in the domain of control and automatization technology
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h

Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

9 Robot Operating Systems

Token / Number:	
Credits:	3 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Prof. Dr. Birte Glimm
Training staff:	Lecturers from the Institute of AI, Ulm University
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	Linear algebra and analysis, programming in Python or C++
Learning objectives:	Students will understand the fundamental theoretical and algorithmic principles behind robotic systems. Students are able to solve robot specific learning problems involving, for example, navigation and mapping, grasping and manipulation, and interaction with humans. They understand the ROS Ecosystem (topics, nodes, messages, services, actionlib) and are able to develop simple applications to control robot motion.
Content:	This course gives an introduction to the Robot Operating System (ROS) including available tools that are commonly used in robotics. With the help of examples, the course provides a starting point for working with robots. The course covers how to create software including simulation, to interface sensors and actuators, and to integrate control algorithms. **Topics:** - ROS architecture: Master, nodes, topics, messages, services, parameters and actions. - Console commands: Navigating and analyzing the ROS system and the catkin workspace. - Creating ROS packages: Structure, launch-files, and best practices. - Simulating with ROS: robot models (URDF) and simulation environments. - Working with visualizations and user interface tools. - Introduction to ROS2.
Literature:	- Thrun, Burgard, Fox "Probabilistic Robotics" - Bishop "Pattern recognition and machine learning" - Russell & Norvig "Artificial intelligence. A modern approach" - Goebel "ROS by Example INDIGO – Volume 1"
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 90 h

Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

10 Learning Robots

Token / Number:	
Credits:	3 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Prof. Dr. Birte Glimm
Training staff:	Lecturers from the Institute of AI, Ulm University
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	Programming in Python or C++, basics of ROS and simulation environments, understanding of machine learning concepts (e.g. Neural Nets, Reinforcement Learning, Computer Vision) may be helpful.
Learning objectives:	Students are able to conduct a project-oriented, scientific work in the area of robotics. They have the ability to define an innovative project topic, acquire skills and technologies required for the project, find related works and base their own work on them where appropriate. The students are further able to work independently in a team and to apply state-of-the-art methods to develop concepts and solutions for the project topic. They can document the results in the form of a scientific report and present their findings in the form of a presentation. They are able to acquaint themselves with a new topic and to conduct a scientific project.
Content:	At the beginning of the project, the range of contents that should be covered in the project will be discussed in detail and the relevant methods will be identified. This is accompanied by a literature search, reading, and discussion phase. In this phase relevant mathematical and computational methods will be selected and discussed. In the second phase, the team starts to implement the experimental design on a simulated robot. Regular team meetings and supervisory consultations lead to an iterated improvement of the software. In the third phase, the thoroughly tested software will be transferred to the robot and tested in a real or simulated environment. The results are written up in a final project report and are presented in a final project presentation. - Definition of concrete project idea. - Project plan incl. systematic literature review. - Evaluation of suitable technologies. - Self-learning of the required technical foundations. - Architecture design. - Implementation. - Integration. - Test. - Deployment.
Literature:	- Thrun, Burgard, Fox "Probabilistic Robotics" - Bishop "Pattern recognition and machine learning" - Russell & Norvig "Artificial intelligence. A modern approach" - Goebel "ROS by Example INDIGO – Volume 1"
Modes of learning and teaching:	Blended Learning Format

Estimation of effort:	Blended Learning: 90 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

11 Modules from “Automatics and Robots” from partner universities

Token / Number:	not specified
Credits:	depends on the modules you choose ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Partner Universities
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Automatics and Robots
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Recommended modules: - Robot Predictive Maintenance
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

12 Business Process Modeling

Token / Number:	BPM
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Winter Semester / 1 Semester
Module authority:	Prof. Dr. Manfred Reichert
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Processes and Data Management
Requirements (contentual):	Basic knowledge of databases, as taught in the module "Fundamentals of database systems".
Learning objectives:	After successfully completing the module, students are able to analyze, model, and optimize business processes on a professional level. They can apply the available methods, concepts, and software tools. Furthermore, they can explain how business processes can be supported by information systems and are able to identify the requirements for implementing such process-oriented information systems. Participants can also describe the essential characteristics, components, and functions of process-oriented information systems and place them within an overall architecture. In addition, they are capable of describing and applying various paradigms for modeling and developing process-oriented information systems, as well as evaluating their advantages and disadvantages. Finally, participants are equipped to implement selected process scenarios using a process management system.
Content:	- Introduction to business process management and case studies - Characteristics of process-oriented information systems - Analysis and optimization of business processes - Tools, languages, and guidelines for process modeling (e.g., Business Process Modeling Notation 2.0) - Modeling and verification of executable processes (i.e., workflows) - Implementation and execution of processes using process management technology - Selected architectural and implementation aspects of process management systems - Concepts and technologies for supporting flexible processes - Current trends in business process management
Literature:	- Lecture script and exercise materials - Reichert, M., Weber, B. (2012), Enabling Flexibility in Process-Aware Information Systems – Challenges, Methods, Technologies: Springer. - Weske, M. (2012), Business Process Management: Concepts, Languages, Architectures, 2. Auflage: Springer. - Dumas, M., La Rosa, M., Mendling, J., Reijers, H. (2013), Fundamentals of Business Process Management: Springer.
Modes of learning and teaching:	Blended Learning Format

Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

13 Project Management - Processes, Activities and Practices

Token / Number:	PMP
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Summer Semester / 1 Semester
Module authority:	Dr. Volker Kraus
Training staff:	All lecturers of the Department of Engineering and Computer Science
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Processes and Data Management
Requirements (contentual):	not specified
Learning objectives:	Students who have successfully completed this module - are familiar with the basics of operational project management. - can independently plan, realize, monitor, and control complex interdisciplinary tasks. - are familiar with the various organizational forms of project management, the coordination of work in project teams, and the requirements and tasks of a project manager. - are proficient in the basic planning techniques of project management - are able to use different methods for planning, controlling, and monitoring processes based on network planning technology. - know the challenges of project management by means of practical examples.
Content:	- Ethics and Compliance. - Motivation, concept formation and basic elements of project management. - Business case and project selection criteria. - Project environment within an organization. - The role of the project manager in the company. - Project phases: initiate, plan, execute, monitor and close. - Scenarios and exercises to enhance knowledge transfer for selected topics. - Knowledge Areas: ◦ Stakeholder Management ◦ Integration Management ◦ Scope management ◦ Scheduling Management ◦ Cost Management ◦ Quality Management ◦ Resource management ◦ Communication Management ◦ Risk Management ◦ Procurement Management
Literature:	- A guide to the project management body of knowledge (PMBOK guide) / Project Management Institute. Sixth edition. Newtown Square, PA; Project Management Institute, 2017. ISBN: 978-1-62825-184-5 - Project Management Institute: Code of Ethics and Professional Conduct. - PMI Practice guides and selected additional literature for the relevant knowledge areas (will be cited during lectures).

Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

14 Data Mining and Knowledge Discovery

Token / Number:	DPM
Credits:	6 ECTS
Language:	English
Turn / Duration:	every Summer Semester / 1 Semester
Module authority:	Prof. Dr. Manfred Reichert
Training staff:	Prof. Dr. Manfred Reichert
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Processes and Data Management
Requirements (contentual):	Algorithmics, data structures, statistics
Learning objectives:	The course aims to present data mining and knowledge discovery concepts, methods and techniques.
Content:	The students will learn various data analysis techniques and will apply these techniques for solving data mining problems using special software systems and tools. Topics: - Introduction - Concept description and definitions - Data preparation - Discovering, ingesting, and exploring data - Transforming data into analytics-ready data - Association rules - Clustering - Classification - Data mining - Model assessment and validation Complementary content: - Network analysis - Process Mining: Event Logs, Process Discovery, Conformance Checking, Log-based Verification (Toolset: ProM, Disco and Celonis) - Data Warehousing: ETL Process, Data Warehouse Components & Architecture, Multi-dimensional data model, ROLAPS

Literature:	- S. Chakrabarti et al, Data Mining. Know It All, Morgan Kaufmann, 2009 - K. Cios, W. Pedrycz, R. Swiniarski, L. Kurgan, Data Mining. A Knowledge Discovery Approach, Springer, 2007 - J. Han, M. Kamber, Data Mining: Concepts and Techniques, 2nd Edition, Morgan Kaufmann, 2006 - P. Tan, M. Steinbach, V. Kumar, Introduction to Data Mining, Addison Wesley, 2006 - D. Larose, Discovering Knowledge in Data. An Introduction to Data Mining, John Wiley & Sons, 2005 - Han, J., Kamber, M., Data Mining: Concepts and Techniques, 1st Edition, Morgan Kaufmann, 2000 - Weka system and documentation (http://www.cs.waikato.ac.nz/ml/weka/) - A. Géron. Hands-on machine learning with scikit-learn & tensorflow: concepts, tools, and techniques to build intelligent systems. Sebastopol, CA: O'Reilly Media, Inc, 2017. ISBN 9781491962299 - H. Mohanty, P. Bhuyan, D. Chenthati, Deepak. Big Data: A Primer. New Delhi: Springer India, 2015, ISBN 9788132224945 - J. Leskovec, A. Rajaraman, J.D. Ullman. Mining of massive datasets, 2nd ed. New York, N.Y.; Cambridge University Press, 2014. ISBN 9781107077232 - R. Garreta, G. Moncecchi, Guillermo. Learning scikit-learn: machine learning in Python. Birmingham: Packt Publishing, 2013. ISBN 978178328193
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	Blended Learning: 180 h
Grading procedure:	The module examination consists of one or more graded written or oral examination(s), depending on the number of participants. The examination(s) form will be announced in good time before the examination(s) is held – at least 4 weeks before the examination date. The module grade is equal to the examination grade(s).
Requirements (formal):	not specified

15 Modules from “Processes and Data Management” from partner universities

Token / Number:	not specified
Credits:	depends on the modules you choose ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Partner Universities
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Compulsory Elective Module, Processes and Data Management
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Recommended modules: - Data Management and Digital Transformation in Industrial Process Automation
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

16 Free Elective Modules from the Master's Degree Program Sensor Systems Engineering

Token / Number:	not specified
Credits:	ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Prof. Dr. Frank Slomka
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Free Elective Module,
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Choose a module from the module catalog of Sensorsystemtechnik (Sensor System Engineering) at Ulm University. Recommended modules: - Pattern Recognition and Deep Learning - Management-Aspects of Systems Engineering I - Management-Aspects of Systems Engineering II
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

17 Free Elective Modules from the Master's Degree Program Business Analytics

Token / Number:	not specified
Credits:	ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	Prof. Dr. Mischa Seiter
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Free Elective Module,
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Choose a module from the module catalog of Business Analytics at Ulm University. Recommended modules: - Machine Learning with Python - Advanced Python Programming
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

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18 Free Elective Modules from partner universities

Token / Number:	not specified
Credits:	ECTS
Language:	English
Turn / Duration:	every Semester / 1 Semester
Module authority:	partner universities
Training staff:	depends on the modules you choose
Integration of module into courses of studies:	Artificial Intelligence for Connected Industries, M.Sc., Free Elective Module,
Requirements (contentual):	depends on the modules you choose
Learning objectives:	depends on the modules you choose
Content:	Choose a module from the module catalog of the partner universities. Recommended modules: - Programming and Communication of a Robotic Arm - Refresh in C & Bash Programming - Network architecture - Complex Networks: Data Analysis and Network Science - Federated and Distributed Learning - Operations Research - Integration of Virtual and Augmented Reality Technologies in Connected Industries - Peer-to-Peer Systems and Blockchain - Datacenter Design and Operations - Contemporary Economic Issues / Company Organization - Ethics and Sovereignty of Digital Infrastructures - Industrial Internet of Things - Algorithm Engineering - Networks – Complements and Applications - Packet Switching and Processing Architectures - Sustainable IoT Technologies
Literature:	Depending on the specific topic.
Modes of learning and teaching:	Blended Learning Format
Estimation of effort:	depends on the modules you choose
Grading procedure:	depends on the modules you choose
Requirements (formal):	not specified

Based on Rev. **333**. Last changed at **06.02.2025**, **15:02** from **kwunderlich**.