# Module Guide
# Applied AI for Digital Production Management

Faculty Applied Natural Sciences and Industrial Engineering
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# MDM-1 Machine Learning and Deep Learning in Production and Logistics

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| Module code | MDM-1 |
| Module coordination | Dr. Sunil Survaiya |
| Course number and name | MDM1101 Machine Learning and Deep Learning in Production and Logistics |
| Lecturer | Dr. Sunil Survaiya |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 manufacturing and logistics market has grown tremendously due to machine learning (ML) and deep learning (DL) deployment. The deployment areas are research and development (R&D), manufacturing, planning, finance, marketing, sales, and other production and logistics areas.

**Machine learning (ML)** is a subset of **artificial intelligence (AI)** , which uses algorithms to learn from the dataset to create self-learning models capable of predicting or classifying the information. Deep learning (DL) is a subset of machine learning. The d **eep neural**

**networks (DNN)** consist of multiple layers of interconnected nodes, each building on the previous layer to refine and optimize the prediction or categorization.

In this course, the students are introduced to different ML models and DL models.
They are able to understand the problem, select the models, evaluate the models, and determine the best solution / approach for a specific application in the area of production and logistics.

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

**Professional competence:**

- understanding machine learning and deep learning
- understanding different algorithms in ML
- understanding modelling concepts and applying of deep learning to various fields of application

**Methodological competence:**

- application of different data collection and preprocessing methods
- application of various machine learning techniques, such as regression
- setting up deep learning models, including various numbers of layers and hyperparameters

**Personal competence:**

- The module Machine Learning and Deep Learning in Production and Logistics (MLDL-PL) teaches and guides students to solve complex tasks and problems.
- The students learn the philosophy of concept building, modeling, analysis, and evaluating, industrial problem and how to apply MLDL technologies to solve them.

**Social competence:**

- Students are able to reflect on the requirements in the field of intelligent systems and transfer them to relevant application scenarios.

## Applicability in this and other Programs

MDM-6 Case Study: "AI Project"

The module provides the necessary theoretical knowledge and transfer possibilities for the application of machine and deep learning in different systems and applications, specifically in production and logistics. Interfaces to mechatronics, electrical engineering, computer engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field

## Learning Content

This module introduces **machine learning** and **deep learning** , in particular, as applied to production and logistics topics. Correspondingly, this module presents a wide spectrum of methods ranging from linear models to deep neural networks.

- Machine learning:  Components, learning and inference
- Machine learning and its classification
- CRISP-DM and OSEMN Frame works
- Probabilities using Venn's diagram
- Fundamentals: prognoses, correlation and causality
- Operating principles of following algorithms with examples:
    - Linear regression (LR), including Maximum likelihood estimation (MLE),
    - principal component analysis (PCA) - Feature Space: feature engineering and dimensional reduction
    - Naive Bayes (NB)
    - Decision trees (DT)
    - K-nearest neighbors (KNN)
    - Support vector machine (SVM)
    - Markov decision process (MDP)
      [Error 2 empty]
- Neural Networks:
    - Biological neurons and artificial neural networks
    - Training with forwards and backpropagation
    - Evaluation and tuning of models: Model metrics and model optimizations
- Introduction to deep learning networks
    - Deep learning architecture - ConvNet, RNN, and GAN
    - selection of a suitable architecture
    - Efficient training on GPUs
    - Applications in production and logistics

## Teaching Methods

- Interactive discussion
- Lecture slides and handwritten notes: i-Learn (online learning platform)
- Scientific research paper and Seminar

- Mathematically solving the ML algorithms.
- Model programming example in the lecture
- Programming assignments (individual)

## Remarks

Skillset Requirement:

- Basic knowledge of logical programming concepts.

## Recommended Literature

Aurélien Géron, "Hands-On Machine Learning with Scikit-Learn, Kreas, and Tensorflow" O'Reilly, third edition, 2022.

Ian Goodfellow, Yoshua Bengio, and Aaron Courville, "Deep Learning", MIT Press, 2016.

Charu Aggrawal, "Neural Network and Deep Learning", Springer verlag GmbH, third edition, 2018

Sebastian Raschka and Vahid Mirjalili, " Python Machine Learning", second edition, 2017

# MDM-2 Advanced Statistical Methods & Optimization

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|---|---|
| Module code | MDM-2 |
| Module coordination | Prof. Dr. Tim Weber |
| Course number and name | MDM1102 Advanced Statistical Methods & Optimization |
| Lecturer | Prof. Dr. Tim Weber |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 module **Advanced Statistical Methods & Optimizatio** illustrates the use and application of statistical methods in a production environment in order to increase effectiveness and efficiency of production lines using a systematic and theory driven approach. Whilst the knowledge about classical statistical methods is deepened, the application of Machine Learning Methods is examined with emphasis on explainable AI.

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

**Professional competence:**

- understanding the use of theory driven optimization methods
- understanding the application of classical statistics to improve effectiveness and efficiency in a production environment
- understanding the use and application of machine learning methods in a production environment

**Methodological competence:**

- application of descriptive statistics
- application of statistical process control (SPC) and regression analysis
- Time Series Analysis and Design of Experiment (DoE)
- Spatial Statistics and Explainable Machine learning
- Production Integration (Brute Force Framework API)

**Personal competence:**

- The module Advanced Statistical Methods and Optimization teaches students how to solve complex tasks and problems in a fast pace production environment.
- The students learn the importance and superiority of a systematic and theory driven approach to solve complex and interdependent tasks over a trial and error approach.
- The students learn to estimate when to use simple statistical methods or when to apply machine learning models.

**Social competence:**

- Students are able to view the problems from the field of statistical methods and optimization from the meta level and to use their competences acquired in the module appropriately and situation-based in individual and group discussions.

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of production data, computer vision and ERP/MES in different systems and applications, specifically in production and logistics. Interfaces to mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field.

## Learning Content

The module **Advanced Statistical Methods & Optimization** provides insight into the importance of methods and approaches in to optimize large

amounts of data. The lecture covers Advanced Statistical Methods:
- descriptive statistics
- normal, lognormal, weibull, poisson distributions
- statistical process control
- training error, test error and crossvalidation
- Classification, regression, and logistic regression
- dimensionality reduction (Principal components analysis)
- Design of Experiment (planning and execution)
- Robust Design
- spatial point patterns (modeling and testing)
- introduction to explainable ML Methods (Decision Trees, random forest)
- Multiobjective Optimization Decision Making Optimization in Manufacturing Systems
e.g. strategic, tactical, operative life cycle lean management and continuous improvement
complexity management

## 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

Trevor Hastie, Robert Tibshirani, Jerome Friedman (2009): The Elements of Statistical Learning, Springer, New York
Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani (2017): An Introduction to Statistical Learning: with Applications in R. Springer, New York
https://www.sixsigmawithr.com/
https://r4ds.had.co.nz/

# MDM-3 Data Management

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|---|---|
| Module code | MDM-3 |
| Module coordination | Prof. Dr. Sebastian Grundstein |
| Course number and name | MDM1103 Production Data Management<br>MDM1104 Application Systems - ERP & MES |
| Lecturer | Prof. Dr. Sebastian Grundstein |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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

This module illustrates the conceptual signal paths ranging from the raw signal acquisition of sensory input variables to the functional use of AI-based software modules. In addition, this module explains which possibilities exist to use large amounts of structured and unstructured data in an industrial context. Application Systems ERP & MES puts the focus on operational IT systems, such as ERP and MES, which are a major source for big data. The importance of IIoT platforms (Industrial Internet of Things) is also discussed.

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

**Professional competence:**

MDM1103 - Production Data Management:

- Understand types of data, data storage, processing and corresponding challenges in industry
- Know methods and tools to create insights out of data
- Understand the technical path from sensor data gathering over communication protocols to data storages
- Ability to differentiate Industrial IoT, Cloud & Edge Data Storage and Processing
- Know the basics of AI in Production incl. feature extraction, processing & statistical evaluation of data as well as processing computer image and video data

MDM1104 - Application Systems - ERP & MES:

- Understand the necessity of an ERP & MES compared to the system landscape in manufacturing companies
- Know how ERP / MES systems are implemented and which business processes are supported by which systems
- Understand the software architecture of the application systems including the role of IIoT platforms.
- Know the most important functions of the respective application software

**Methodological competence:**

- Understanding methods and tools for data storage, processing and analysis in industrial environments
- Know how to use ERP/MES/IIoT in a company including introduction of those systems

**Personal competence:**

- Ability to implement own methods and approaches and can argue against competing methods

**Social competence:**

- View the problems from the field of advanced intelligent systems from the meta level and to use their competences acquired in the module appropriately and situation-based in individual and group discussions

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of structured and unstructured production data and ERP/MES in different systems and applications, specifically in production and logistics. Interfaces to mechatronics, production engineering and industrial engineering are discussed.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field

## Learning Content

**MDM1103 - Production Data Management:**

- Basic steps of data preparation
- Data Sources and Data Types
- Good and bad data quality
- Data Matching
- Types of data storages
- Structured and unstructured data
- Data Semantics
- Types of data analytics
- Overview of descriptive analytics
- Visualizations and Dashboards
- Use Cases Digital Shopfloor Management & Data Value Stream
- Communication technologies
- Types of Sensors
- Concept of retrofit and retrofitting a machine
- IoT Protocols
- Sensor based Use Cases
- IoT Overview & Applications
- IoT Ecosystem
- Industry 4.0 Architecture
- Edge & Cloud computing
- Implementation approach & methodologies
- Types and use cases of artificial intelligence (AI)
- Mathematical and statistical foundations of AI
- Machine Learning (ML), deep learning & neural networks; focus CNN in image processing
- Types of advanced analytics
- Autonomous solutions

**MDM1104 - Application Systems - ERP & MES:**

- Definition & relevance of ERP & MES
- Historic development
- Role of an ERP & MES compared to the system landscape in manufacturing companies
- Typical processes supported by ERP & MES
- Overall project plan & approach to introduce ERP/ MES

- Main differences of greenfield implementation vs. "update"
- Success factors in system introduction
- Typical cost & resources needed
- Redefine business processes as preparation of a ERP / MES project
- Support by modern tools such as Process Mining
- Selecting the right vendor / implementation partner
- Role of IoT / IIoT platforms in comparison to traditional ERP & MES
- Future Trends of systems and system architecture
- Typical process landscape as basis for ERP systems
- General architectural considerations in process & system design
- Core processes supported by MES vendors: Production scheduling, Advanced planning & scheduling, Information Management, Data Acquisition, Resource Management & Material Management
- Functionalities that some MES vendors or standalone provider offer: Production performance tracking, Quality Management, Shopfloor-Management, Energy Management
- Interface to Business Intelligence Systems & BI for vs. ERP & MES functionalities

## 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

A. Petrov, "Database Internals: A Deep Dive into How Distributed Data Systems Work", O'Reilly Media, 2019.

M. Goodrich, et al., "Data Structures and Algorithms in Python", John Wiley & Sons, 2013.

N. Gronau, ERP-Systeme. Architektur, Management und Funktionen des Enterprise Resource Planning, De Gruyter, 2021.

E. Raj, "Engineering MLOps: Rapidly build, test, and manage production-ready machine learning life cycles at scale", Packt, 2021.

S. Ranjan, S. Applied Deep Learning and Computer Vision for Self-Driving Cars, Packt Birmingham Mumbai, S. Ranjan, S. Senthamilarasu, 2020.

R. Deisenroth, et al., Lehrbuch für digitales Fertigungsmanagement: Manufacturing Execution Systems MES, Springer Vieweg, 2021.

# MDM-4 Production and Logistic Management

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|---|---|
| Module code | MDM-4 |
| Module coordination | Ginu Paul Alunkal |
| Course number and name | MDM1105 Production and Logistic Management |
| Lecturer | Ginu Paul Alunkal |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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

This module provides an overview of production and logistics management activities. In this context, production management consists of planning, organizing, directing and controlling of all production activities to convert raw materials into finished goods or products. It also deals with decision-making regarding the quality, quantity, cost, etc., of production. Logistics management covers the movement of products from the stage of raw materials to the consumer end product.

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

**Professional competence:**

- Know methods and tools in production management, i.e. planning, organizing, controlling etc. of production processes
- Know methods and tools in logistics management, i.e. sourcing, procurement, storing, moving goods throughout the entire supply chain

**Methodological competence:**

- understanding the interdependencies of technology, production and logistics
- understanding methods, tools and business processes in production and logistics management

**Personal competence:**

- analysis and discussion of technical issues in production and operation
- students are able to apply methods for decision making in logistics and produciton
- they are able to apply methods to optimize processes in the fields of production and logistics

**Social competence:**

- The students use their competences acquired in the lectures and are able to discuss advantages and disadvantages of various application cases

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application methods and production/logistics related know how in various application scenarios. It creates interfaces to courses of study such as mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field

## Learning Content

The lecture **Production and Logistics Management** provides insight into the importance of methods and approaches taken in production and logistics planning, operation and improvement. The lecture covers:

- Strategic vs. Operative vs. Tactical production management
- Production planning and control
- Scheduling and capacity control
- Lean Production & Kanban
- Six Sigma
- Organization and material flow

- Materials logistic
- Supply Chain Management
- Forecasting

## 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 Crandall, R. E. (2014) Principles of Supply Chain Management , 2nd edn, CRC Press.
2 Walley, P. (2017) Introduction to operations management, in The Open University (2017) B207 Readings Block 1: Big ideas in Organisations , Milton Keynes, The Open University.
3 Chapman, Stephen N. The fundamentals of production planning and control, Pearson
4 Hopp et.al., Factory Physics, Waveland Press
5 Sharma, "Operations Research: Theory and Application", MACIN

# MDM-5 Digital Tools in Development and Production

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|---|---|
| Module code | MDM-5 |
| Module coordination | Ginu Paul Alunkal |
| Course number and name | MDM1106 Digital Tools in Development and Production |
| Lecturer | Ginu Paul Alunkal |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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

This module provides insight to selection and use of methods and tools which, in the course of increasing digitalization, are increasingly becoming important in development and production.

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

**Professional competence:**

- methods and technologies for development and implementation of automated production processes: design, selection and programming of industrial robots and PLC programming

- know the most important technologies and production processes (types of AM) as well as design and design digitalization regarding additive manufacturing like CAD/CAE
- Use of Virtual / Augmented Reality in development, production and logistics
- Students can design, criticize, and implement mobile human-machine interfaces that meet the guidelines for usability, user experience, and experience quality.

**Methodological competence:**

- understanding the interdependencies of technology, production and digitalization taking the example of additive manufacturing
- understanding mode of operation, future potential and limitations of virtual and augmented reality.

**Personal competence:**

- analysis and discussion of technical issues in automated production environments
- students learn what to focus on when evaluating or using methods and tools in production/logistics planning
- conduct CAE analysis and construct simple AR/VR applications

**Social competence:**

- The students use their competences acquired in the lectures and are able to discuss advantages and disadvantages of various application cases

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application methods and production/logistics related know how in various application scenarios. It creates interfaces to courses of study such as mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field

## Learning Content

The lecture **Digital Tools in Development and Production** provides insight into the importance of methods and approaches taken in development, production and logistics planning. The lecture covers:

**Automated production processes and industrial robotics**

- methods and technologies for development and implementation of automated production processes
- capabilities and limitations of automation systems in production
- programming of programmable logic controllers
- selection and programming of industrial robots

**VR/AR in production and logistics**

- Virtual and Augmented Reality systems and applications
- CAD and CAE softwares and applications
- VR / AR applications in development and production

**Additive Manufacturing**

- Technology, Materials and Production
- Design for additive manufacturing
- Data processing

## Teaching Methods

- Seminar-like teaching with joint exercises as well as presentations to deepen the knowledge achieved through application
- Laboratory sessions for PLC programming, CAD/CAE
- i-Learn (online learning platform)

## Recommended Literature

K.H. John, M. Tiegelkamp: IEC 61131-3 - Programming Industrial Automation Systems, Springer, Berlin, 2014

Lunze, J.: Automatisierungstechnik, Oldenbourg Verlag, 2. Auflage, 2008

Dörner et al.  Virtual und Augmented Reality (VR/AR), Ralf Dörner, Wolfgang Broll, Paul Grimm, Bernhard Jung, 2. Auflag, Springer Verlag, 2019

W. Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Pearson

Roland Siegwart et.al., 'Introduction to Autonomous Mobile Robots' by MIT Press

N.Correll et.al., 'Introduction to Autonomous Robots: Mechanisms, Sensors, Actuators and Algorithms' by MIT Press

Ian Gibson, David Rosen & Brent Stucker, 'Additive Manufacturing Technologies' by Springer

# MDM-6 Case Study "AI Project"

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|---|---|
| Module code | MDM-6 |
| Module coordination | Dr. Sunil Survaiya |
| Course number and name | MDM1107 Case Study "AI project" |
| Lecturer | Dr. Sunil Survaiya |
| Semester | 1 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 **"AI Project"** provides students with a platform for hands-on experience to develop programming skills for AI in production and logistics fields. The students have to select a current scientific research paper application. related to the use of AI in production. The students are given an opportunity to deal with these topics independently and creatively. The intention of this case study is to introduce the students to a practical and industry-oriented way of solving technical problems along a professional AI project handling path.

Upon completion of this module, the students will be able to gain confidence and execute AI projects in production and logistics by themselves with following competences.

**Professional competence:**

- In depth knowledge of a specific subarea of manufacturing, logistics, and the use of AI in these fields.
- Practical experience in executing an AI project includes project planning, teamwork, time management, and execution.

**Methodological competence:**

- Students are able to learn the process of searching, reading, and selecting a scientific research paper.
- Students are able to implement, evaluate and optimize the algorithms for the selected specific fields of application.

**Personal competence:**

- The case study of AI projects teaches and inspires students to solve complex tasks in teams with distributed task areas.
- The students learn to analyse, synthesize, and evaluate a task in relation to the execution of AI projects in an application.
- Students are required to present the progress of their respective projects in regular meetings.

**Social competence:**

- The students are able to consider the scientific problems from different perspectives and to use their competences acquired in the module appropriately and situation-basedly in individual and group discussions.
- The students are able to consider questions in the area of AI in production and logistics on the basis of case studies, to deepen their competences acquired in the module in group work and to use them in a prepared manner.

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge to gain a deeper understanding of AI methods in the production and logistics domains and the AI project execution for a specific area of application. This gives rise to fields of study including industrial engineering, production engineering, and mechatronics.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field.

## Learning Content

- Introduction to Artificial Intelligence (AI)
- Forward feed and back propagation

- Model evaluation: model metrics and optimization.
- Basic logical programming concepts with Python.

The above topics give students an insight into artificial intelligence and development programming skills, which one can apply to the " **Case Study AI Project.** " The fields of machine learning and deep learning in production and logistics, advanced statistical methods and optimization, data management, and production data management (acquisition and control) are available for selection as case study topics.

The ultimate goal is to understand and test the techniques available. Furthermore, it is imperative to comprehend the boundaries and potential of machine learning and deep learning in relation to traditional optimization techniques.
**NOTE:** The case study "AI project" can vary each semester.

**Recommendation:**
The students are recommended to take MDM-1: MLDL-PL with the MDM-6 course.

## Teaching Methods

- Scientific research paper
- Model simulation and optimization
- Programming
- Application of evaluation techniques
- Progress presentation

## Remarks

The case studies are examined as a so-called "Prüfungsstudienarbeit" (student research report) and are therefore not a classic examination. Students' theoretical knowledge is particularly applied in practice to the case study themes, enabling them to independently analyze problems and implement suggested solutions. By identifying and assessing linkages, this enhances the knowledge transfer into practice and the focused deepening of the gained technical and methodological capabilities.

## Recommended Literature

1 bin Uzayr, Sufyan,"Optimizing Visual Studio Code for Python Development. Developing More Efficient and Effective Programs in Python", first edition.CA: Apress; Imprint Apress (Springer eBook Collection), 2021. Online available unter https://link.springer.com/ content/ pdf/10.1007%2F978-1-4842-7344-9.pdf, zuletzt geprüft am 16.01.2022.
2 Gad, Ahmed Fawzy Mohamed, "Building Android Apps in Python Using Kivy with Android Studio. With Pyjnius, Plyer, and Buildozer". CA:

Apress, Berkley 2019.
Online, available unter https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=5945083.

3 Raschka, Sebastian, "Python machine learning. Unlock deeper insights into machine learning with this vital guide to cutting-edge predictive analytics.". Birmingham, Mumbai: Packt Publishing, open source (Community experience distilled), 2016

# MDM-7 Technology and Innovation Management

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|---|---|
| Module code | MDM-7 |
| Module coordination | Prof. Dr. Sebastian Grundstein |
| Course number and name | MDM2101 Technology and Innovation Management |
| Lecturer | Prof. Dr. Sebastian Grundstein |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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

This module provides an overview of technology and innovation management activities. It highlights two different points of view: (1) technology and innovation management in large companies with established processes and procedure and (2) from a startup's point of view with focus on operative execution of coming up and implementation of new business ideas.

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

**Professional competence:**

- Know methods, tools and processes for selecting, operating and improving technology and innovation processes
- Know essential methods and have know how to create and follow up on new, innovative ideas
- Creating a business plan for a new venture (e.g., a tech start-up)

**Methodological competence:**

- understanding the challenges of increasing complexity in technology and company organization
- students have the capability to analyze and improve existing technology and innovation management approaches
- know relevant creativity methods for innovation
- they are able to create a business model for a startup

**Personal competence:**

- analysis and discussion of technical issues in technology and innovation management
- the students reflect on their personal strengths & weaknesses working in innovation management
- Students can assess whether setting up a business is an option for them

**Social competence:**

- Students understand the impact of culture and behaviour on innovation as well as their individual contribution
- The students use their competences acquired in the lectures and are able to discuss advantages and disadvantages of various application cases

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application methods and production/logistics related know how in various application scenarios. It creates interfaces to courses of study such as mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field

## Learning Content

The lecture **Technology and Innovation Management** provides insight into the importance of methods and approaches taken in the development and implementation of new business and/or product ideas. The lecture covers:

- Increasing complexity of technology (increasing development times, shorter technology life cycles
- Technological innovation and intellectual property
- Innovation management in line with company strategy and organization
- Development and implementation of an innovation process
    - Sources of Innovation, i.e. idea generation
    - innovation portfolio
    - idea implementation
    - monitoring and improvement of the innovation process
- Personal behaviour & corporate culture in innovation processes
    - Self management
    - Communication
    - Meeting management
    - Giving feedback
    - Moderation
    - Conflict resolution
    - Professional presentation(s)
- Creativity techniques for innovation
- New Venture (Business Planning)
    - Business Idea
    - Business Plan
    - Core Team
    - Execution Timing
    - Market Research
    - Competitor Analysis
    - Product Development
    - Business Model
    - Digital Business & Platform business models

## Teaching Methods

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

## Remarks

The part **"Business Planning"** requires the students to create & upload a business plan for a venture of their choice. The purpose of this is to apply what they have learnt directly in a context of their choice. Feedback sessions are organised during the semester where students can ask and discuss questions about their business plan

## Recommended Literature

Gassmann, O.: Geschäftsmodelle entwickeln : 55+ innovative Konzepte mit dem St. Galler Business Model Navigator. München. Hanser. 2021.

Wördenweber, B; Eggert, M; Größer, A. Technologie- und Innovationsmanagement im Unternehmen: Lean Innovation. Springer Berlin Heidelberg.2020.

Gassmann, O; Sutter, P. Digitale Transformation gestalten: Geschäftsmodelle Erfolgsfaktoren Checklisten. Carl Hanser Verlag GmbH & Co. KG. 2023.

# MDM-8 Advanced Intelligent Systems

| | |
|---|---|
| Module code | MDM-8 |
| Module coordination | Prof. Dr. Tim Weber |
| Course number and name | MDM2102 Big Data Processing & Analytics<br>MDM2103 Natural Language Processing |
| Lecturers | Ginu Paul Alunkal<br>Prof. Dr. Tim Weber |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 module **"Advenced Intelligent Systems"** imparts knowledge on how to save and process big data quantities efficiently within the context of production and logistics. The students learn to develop and implement Big Data systems including the use of large sets of data for learning of deep learning models. They will be able to identify typical problems related to big data, such as data quality and bias, and how to solve those problems. In addition, this module explains, how natural language is processed and understood.

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

**Professional competence:**

- the students understand the concepts of the most popular approaches in big data and deep learning
- they know and understand basic concepts of natural language processing and understanding

**Methodological competence:**

- students have the capability to develop big data and deep learning related programs
- they know how to use NLP techniques for understanding, processing and generation of natural language

**Personal competence:**

- the students are able to implement their own methods and approaches and can argue against competing methods
- they are able to develop NLP programs, e.g. text classification or chatbot operation

**Social competence:**

- Students are able to view the problems from the field of advanced intelligent systems from the meta level and to use their competences acquired in the module appropriately and situation-based in individual and group discussions.

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer possibility for the application of big data and natural language processing in different systems and applications, specifically in the area of production and logistics. Interfaces to mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field.

It is recommended that module MDM-1 "Machine and Deep Learning in Production and Logistics" is completed before taking this module.

## Learning Content

This module introduces how to save and process big data sets efficiently.

- Introduction: 3 Vs, history of big data, selected big data use cases
- Complexity analysis: time complexity, O, Omega, Theta, o, and O tilde notations, space complexity, recurrence relations, master theorem, dynamic programming
- Multithreading: parallelism and concurrency, creating threads, global interpreter lock (GIL)
- Databases: ER diagrams, relational databases, database management systems, queries, indexes, normalization, transactions
- Big data architectures: distributed systems, MapReduce, CAP theorem, speedup through GPUs and FPGAs
- Big data, small data, all data: data quality, biases in data sets, small sample size problems
- MLOps: project lifecycle, challenges, operations, principal components, pipelines, best practices
- Quantum computing: qubits, quantum logic gates, quantum computers, quantum algorithms
- Selected big data infrastructures, frameworks, libraries and tools

In addition, this module explains how natural language is processed so that understanding of language becomes possible for machines.

The course for Natural Language Processing will be giving an overview into the implementation of different AI models for fulfilling NLP tasks using TensorFlow. The contents in this course can be summarized as:

- Introduction to NLP
- Word2vec
- CNN for sentance classification
- RNN in NLP
- Text generation with LSTM or GRU
- NMT for machine translation
- Transformers and LLM

These contents will be designed so that the students will get trained on data preprocessing, vectorization, building basic neural networks, implementing different popular NLP models, understanding the limitations of these models and evaluating the performance using relevant metrics.

## 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

A. Petrov, "Database Internals: A Deep Dive into How Distributed Data Systems Work", O'Reilly Media, 2019.
M. Goodrich, et al., "Data Structures and Algorithms in Python", John Wiley & Sons, 2013.
E. Raj, "Engineering MLOps: Rapidly build, test, and manage production-ready machine learning life cycles at scale", Packt, 2021.

Geron, Hands-On Machine Learning with Scikit-Learn, Keras, and Tensorflow: Concepts, Tools, and Techniques to Build Intelligent Systems, O'REILLY, Nov. 2022

Thushan Ganegedara, Natural Language Processing with Tensor-Flow Second Edition, Packt Publishers, July 2022

Hobson Lane, Cole Howard, and Hannes Max Hapke, Natural Language Processing in Action, Manning, April 2019

# MDM-9 Case Study Intelligent Systems in Production

| | |
|---|---|
| Module code | MDM-9 |
| Module coordination | Prof. Dr. Tim Weber |
| Course number and name | MDM2104 Case Study Intelligent Systems in Production |
| Lecturer | Prof. Dr. Tim Weber |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 **"Intelligent Systems in Production"** takes up current case examples related to the application of big data processing or natural language processing. Furthermore, students are given the opportunity to deal with these topics independently and creatively.

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

**Professional competence:**

- The module provides in depth knowledge of a specific subarea of intelligent systems in the area of big data processing or NLP in production and/or logistics

- provides practical experience in this field

**Methodological competence:**

- Students are able to execute a topic related literature search in this field
- Students are able to evaluate, use and assess methods of big data processing and/or NLP techniques used in production and logistics

**Personal competence:**

- The Case Study " Intelligent Systems in Production " teaches students how to solve complex tasks in teams with distributed task areas. The students learn to analyze, synthesize and evaluate a task in relation to big data processing or NLP applications in production and logistics.

**Social competence:**

- The students are able to use big data processing and NLP methods on the basis of case studies and to deepen their competences acquired in the module in group work and to use them in a prepared manner.
- The students are able to consider the problems from different perspectives and to use their competences acquired in the module appropriately and situation-based in individual and group discussions.

## Applicability in this and other Programs

The module provides the necessary theoretical knowledge and transfer capability to gain a deeper understanding of big data processing and natural language processing in the area of production and logistics.

This creates interfaces to courses of study such mechatronics and production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering 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

- Literature research

- Simulations
- Application of evaluation 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 analyze 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 recognizing connections and evaluating them.

## Recommended Literature

- Unpingco, José. (2021): Python Programming for Data Analysis. 1st ed. 2021: Springer International Publishing; Imprint Springer (Springer eBook Collection).
- bin Uzayr, Sufyan (2021): Optimizing Visual Studio Code for Python Development. Developing More Efficient and Effective Programs in Python. 1st ed. 2021. Berkeley, CA: Apress; Imprint Apress (Springer eBook Collection). Online verfügbar unter https://link.springer.com/content/pdf/10.1007%2F978-1-4842-7344-9.pdf, zuletzt geprüft am 16.01.2022.
- Gad, Ahmed Fawzy Mohamed (2019): Building Android Apps in Python Using Kivy with Android Studio. With Pyjnius, Plyer, and Buildozer. Berkeley, CA: Apress L. P. Online verfügbar unter https://ebookcentral.proquest.com/lib/kxp/detail.action?docID=5945083.
- Raschka, Sebastian (2016): Python machine learning. Unlock deeper insights into machine learning with this vital guide to cutting-edge predictive analytics.
- Birmingham, Mumbai: Packt Publishing open source (Community experience distilled).

# MDM-10 Digital Production Systems

| | |
|---|---|
| Module code | MDM-10 |
| Module coordination | Prof. Dr. Sebastian Grundstein |
| Course number and name | MDM2105 Cyber-physical production systems & Smart Factory<br>MDM2106 Simulation of Production Systems |
| Lecturer | Prof. Dr. Sebastian Grundstein |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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

Cyber-physical production systems consist of autonomous and co-operative elements and subsystems that are connected within and across all levels of production, from processes through machines up to production and logistics networks.

Simulation of Production Systems covers the identification of essential resources and flows, such as energy, material and data, and the creation of suitable models and their dynamic simulation using different simulation techniques (event-discrete, agent-based, system dynamics). It includes data availability and provision for the simulation, introduction to the simulation software and simulation of an example environment.

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

**Professional competence:**

- the students understand the concepts of cyber-physical systems, in particular with the focus on production systems and smart factory
- they know and understand autonomous and co-operative elements in production and technical solutions for their communication
- Students are able to create and run simulation studies on selected problems in production and/or supply chain

**Methodological competence:**

- students have the capability to analyze and improve cyber-physical production systems
- students have the capability to develop manufacturing simulation related programs
- they know how to represent manufacturing data in models and are able to simulate them dynamically

**Personal competence:**

- Students are able to implement their own methods and approaches and can argue against competing methods
- Students can better assess their affinity for quantitative solution methods with regard to their later professional career

**Social competence:**

- Students are able to view the problems from the field of advanced intelligent systems from the meta level and to use their competences acquired in the module appropriately and situation-based in individual and group discussions.

## Applicability in this and other Programs

The module provides the necessary cyber-physical production systems and production simulation. Interfaces to mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering or a closely related field.

## Learning Content

The lecture **Cyber-physical production systems** covers:

- Introduction to Cyber Physical Production Systems (CPPS) & Smart Factory

- Basic Technologies enabling a Smart Factory
- Elements of a Smart Factory (e.g., automation, connectivitiy, sustainability, cybersecurity)

The lecture **Simulation of Production Systems** covers:

- Agent based modeling
- System Dynamics modeling
- Discrete-event modeling
- Supply Chain Modeling

with AnyLogic and Anylogistix on production and supply chain related problems.

## Teaching Methods

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

## Recommended Literature

Ilya Grigoryev: Anylogic in three days. A quick course in simulation modelling. 6th ed 2023.

Dmitry Ivanov: Supply Chain Simulation and Optimization with Anylogistix. 5th, updated edition, Berlin School of Economics and Law.

Jerry Banks et al.: Discrete-Event System Simulation. 5th ed. Pearson 2013.

DIN SPEC 91345 (RAMI 4.0). Beuth Verlag 2017.

A W Colombo et.al.: Industrial Cloud-Based Cyber-Physical Systems. The IMC-AESOP Approach. Springer Verlag, 2014. https://link.springer.com/book/10.1007/978-3-319-05624-1

# MDM-11 Case Study Production Systems

| | |
|---|---|
| Module code | MDM-11 |
| Module coordination | Prof. Dr. Sebastian Grundstein |
| Course number and name | MDM2107 Case Study Production Systems |
| Lecturer | Prof. Dr. Sebastian Grundstein |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 Production Systems** , students independently work in groups on a coherent task taken from the area of production systems in order to practice the content of previous or parallel lectures on the area of production systems. Contributions from industry experts can deepen special topics further. The intention of this case study is to introduce the students to a practical and industry-oriented way of technical problem solving.

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

**Professional competence:**

- understanding and applying methods of development, construction, testing & assessing or simulation of production systems

- understanding and applying methods, e.g. software, as part of cyber-physical production systems
- understand the complexity of real production systems and learn to prioritise and schedule improvements

**Methodological competence:**

- application of different approaches to add analyze, simulate or improve a production system
- identify opportunities and limits of production systems in development and during operation
- learn to work with incomplete information based on hypotheses

**Personal competence:**

- The Case Study " Production Systems " teaches students how to solve complex tasks in teams with distributed task areas. The students learn to analyze, synthesize and evaluate a task in relation to production systems in an application-related manner.
- Students are required to present the progress of their respective project in regular meetings.

**Social competence** :

- The students are able to consider production systems on the basis of case studies as well as to deepen their competences acquired in the module in group work and to use them in a prepared manner.
- The students are able to consider the problems from different perspectives and to use their competences acquired in the module appropriately and situation-based in individual and group discussions.
- The students give other students constructive feedback on their work and receive feedback on their work

## Applicability in this and other Programs

Based on the lectures of this course, the module provides additional specific knowledge in the respective field and the transfer capability to understand production systems. This creates interfaces to courses of study such as mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial engineering 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 vary each semester.

## Teaching Methods

- i-Learn (online learning platform)
- Literature research
- Simulations
- Development, construction and building of intelligent systems
- Application of assessment techniques
- Presentation methods
- 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 "portfolio exercise" 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 analyze 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 recognizing connections and evaluating them.

## Recommended Literature

Bungartz, Hans-Joacheim et al.: Modellbildung und Simulation, eine anwendungsorientierte Einführung, Springer 2009, DIN SPEC 91345:2016-04

AnyLogic 7 in Three Days: A Quick Course in Simulation Modeling Paperback ? 20 Mar. 2015, English edition by Ilya Grigoryev (Autor)

A W Colombo et.al.: Industrial Cloud-Based Cyber-Physical Systems. The IMC-AESOP Approach. Springer Verlag, 2014. https://link.springer.com/book/10.1007/978-3-319-05624-1

A W Colombo et.al.: Digitalized and Harmonized Industrial Production Systems: The PERFoRM Approach. Taylor and Francis / CRC-Press 2019. https://doi.org/10.1201/9780429263316,

DIN SPEC 91345 (RAMI 4.0). Beuth Verlag 2017.

# MDM-12 Subject-Related Elective Course (FWP)

| | |
|---|---|
| Module code | MDM-12 |
| Module coordination | Dr. Sunil Survaiya |
| Course number and name | Computer Networking and Secure Network Management Interactive Online (CNSM)<br>Tele-Experiments with Mobile Robots<br>Data Acquisition and Control using LabVIEW<br>Quality Management Methods & Tools |
| Lecturers | Dr. Sunil Survaiya<br>Prof. Jürgen Wittmann<br>Virtuelles Angebot vhb |
| Semester | 2 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | compulsory course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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)
- Tele-Experiments with Mobile Robots

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, production engineering, industrial engineering 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 results from the respective FWP subject.

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

## Objectives

The course is divided into two parts:
Part I: Fundamentals of Computer Networking
Part II: Secure Computer Network Management
**Part I: Fundamentals of Computer Networking**

The standard ISO/OSI computer networking model is introduced first and compared with the TCP/IP model based on RFC specifications; the roles and features of each of the layers of both models are presented.

The most important protocols and services of each layer used for networking the local and remote computers are also presented in the form of a top-down approach. All protocols are analyzed hands on using remote virtual labs and analyzer tools such as Wireshark. The roles and the main features of the network components, i.e. hub, switch, router and DNS server are addressed as well. Their operations are shown and tested using the remote virtual labs and experimental virtualized network configurations. There is also a project (programming of a simple application based on TCP and UDP sockets) which is a prerequisite for admission to the final exam.

Teaching resources offered: tutorials, lab instructions, virtualized ready set network configuration (downloadable on students? PCs), case studies, forums, exam patterns, student support materials
**Part II: Secure Computer Network Management**

The role and the objectives of network management (NM) for an organization are initially addressed. Various standard and private Management Information Bases (MIB) and remote MIBs are presented. The different types of network management tools, i.e. OpenNMS, NetFlow Collector, as well as the network management protocols SNMPv2/v3,

NetFlow and OpenFlow network management protocols are experienced hands on based on virtualized experimental virtual networks and software tools.

Experiments are also conducted on the fundamentals of the Reconnaissance and DoS network attack types and their effects on network components and network applications to gain hand-on experience. An understanding is gained of the need for protection tools and the various types of tools. Legacy protection tools and other techniques for protecting the network components (FW, IPS, VPN) are addressed. Furthermore, secure management concepts (e.g. migration to NGFW, NGIPS, Sandbox) for the purpose of protecting against new types of attacks (e.g. ransomware, protocol anomalies) are implemented. In addition, awareness is raised of the security assurance requirements of organizations for network protection.

Teaching resources offered: tutorials, lab instructions, virtualized ready set network configuration (downloadable on students PCs), case studies, forums, exam patterns, student support material

Collaborative and cumulative project for Part II: Program and implement a secure Software Defined Network (SDN) using Snort as the intrusion attacks detector. The project is carried out in a collaborative manner by international teams of 2-3 students. The project is cumulative, i.e. each project step is based on the framework provided by the prior steps. The project is mandatory for admittance to the final exam.

## Learning Content

**Content:**

Part I: Fundamentals of Computer Networking

- Computer Networking Terminology
- Computer Networking Architecture
- Application Layer
- Transport Layer
- Network Layer
- Multiprotocol Label Switching (MPLS)
- Data Link Layer wired networks
- Data Link Layer wireless networks
- Multimedia Technology

Part II: Secure Computer Network Management

- Surveys of Fundamentals on Computer Networks
- Network Management (NM) Architecture
- Management Information Bases (MIBs)
- NM Protocols
- Managing Network Security
- Managing Network Protection

**Detailed content:**

**Part I: Fundamentals of Computer Networking**

- Computer Networking Terminology
- Computer Networking Architecture: ISO/OSI versus TCP/IP models, role of the layers, interfaces, and protocols between layers
- Application Layer: services, application protocols (HTTP, FTP, E-Mail, DNS)
- Transport Layer: TCP protocol (sockets, analyze, error cases), UDP protocol (analyze), application programming using TCP/UDP Sockets
- Network Layer: addressing in global networks, subnetting, routing in Internet, routing algorithms, routing protocols (RIPV2 & OSPF), routing tables, ICMP protocol, protocol analyses, router operation
- Multiprotocol Label Switching (MPLS)
- Data Link Layer wired networks: CSMA/CD protocol, Ethernet versions, Ethernet analyses, VLAN principle, WAN protocols, switch operation
- Data Link Layer wireless networks: CSMA/CA protocol according to IEEE 802.11, message analyzes, access point operation
- Multimedia Technology: VoIP operation, RTP, RTCP, SIP, G.711, G.723 protocols, analyses of VoIP protocols

**Part II: Secure Computer Network Management**

- Surveys of Fundamentals on Computer Networks: MAC Control, TCP/IP Stack, STP protocol, VLANs, subnetting, routing algorithms, routing protocols, routing tables, QoS, CoS
- Network Management (NM) Architecture: reference model, legacy NM functionalities, proxy architecture, policy governed architecture, EVAS NM architecture (Endpoint Visualization, Access and Security), Software Defined Networks architecture (SDN), Mininet
- Management Information Bases (MIBs): standard and private MIBs (MIB II, RMON1, RMON2, ASN.1), language, Structure of Management Information (SMI), Basic Encoding Rules (BER), NM Systems (OpenNMS, NetFlow Collector)
- NM Protocols: SNMPv2, Secure SNMPv3, NetFlow, NetCONF, OpenFlow for SDNs, Case Study based on Mininet
- Managing Network Security: Confidentiality-Integrity-Availability-Model, managing Network Access Control (NAC), legacy NAC using Std. IEEE 802.1X and RADIUS; Case Study: NAC using Policy Governed Network CISCO-ISE; managing Transport Layer Secure Connections (SSL, TSL); managing Network Layer Security (IPSec and VPNs); managing Network Access Decision Control using Policy Engines
- Managing Network Protection: Type of Attacks (Reconnaissance, Denial of Service (DoS), DDoS), case studies of network attacks, managing protection methods (packet filtering, ACL, PAT/NAT, FW, VLAN, Honeypots, next generation FW (NGFW), next generation IPS (NGIPS), managing Sandboxing Protection)

**Lab assignments:**

1. Managing Static/RIPv2/OSPF routing
2. Monitoring/controlling CNs using SNMP v2 & v3 and MIBII technology
3. Monitoring the CN Security using OpenNMS and SNMP
4. Monitoring the CN Security using NetFlow Prot. and NetFlow Collector
5. Configuring/analyzing CN protection using FW and NAT tools
6. Programming, deploying, and analyzing various CN attacks (Reconnaissance, DoS)
7. Configuring/analyzing VPN based traffic protection using OpenVPN
8. Configuring/analyzing IPS protection using Snort
9. Configuring/analyzing network attacks using Cuckoo Sandbox
10. Monitoring/controlling SDN-based CNs using Mininet

All assignments are carried out using the virtual lab container with network components and software packages already installed. The network components are based on virtual machines and open source software tools such as Wireshark, Vyos Router supporting MIBII and SNMPv2&3, NetFlow Agents, OpenNMS, NetFlow Collector, Snort, OpenVPN, Mininet, and OpenvSwitch. All assignments are mandatory for admittance to the exam.

## Type of Examination

written ex. 90 min.

## Methods

Virtual seminar

Forms of interaction with the system/lecturer:
e-mail, cooperation between learner and supervisor during task processing, exercises for self-study

Forms of interaction with fellow learners:
e-mail, forum

# Tele-Experiments with Mobile Robots

## Objectives

The idea of this course is to use modern teleoperation and make robotics more approchable. Experiments part of this course can be performed via internet and these include experiments in robot kinematics, navigation of remote rovers, path planning and sensor data acquisition and processing. The real robot used in the experiments is a four

wheeled ackermann steered real wheel driven indoor mobile robot designed and built at our department specifically for remote experiments.

## Learning Content

Tele-Experiments with mobile robots" is an attempt to put basic robot theory and its implementation together to bring to students an interesting and practical course. Given that this tele-course is simultaneously used as part of regular on-site lectures, the course contents are kept up-to-date and always accessible. The experiements available here include a carefully selected mixture of real-world and simulation of robotic principles. Various topics in field robotics including kinematics, navigation principles, path planning, theoretical analysis and inverse kinematics, sensor data acquisition and processing are discussed and students are presented with challenging quizzes before beginning the experiments. Sensors are also chosen so that students get confusing results and are supposed to spend time thinking about the acquired sensor values and how to interpret those. Time delay concepts in robot teleoperation on variable bandwidth networks are also transparently presented to users as part of involuntary learning.

Contents:

1) Kinematics of a car-like mobile robot
2) Navigation control of a car-like mobile robot
3) Path planning of a car-like mobile robot
4) Modelling of the forward and inverse kinematics of differential drive robot
5) Sensor data acquisition and processing

## Type of Examination

written student research project

## Methods

Virtual internship

Forms of interaction with the system/lecturer:
e-mail

Forms of interaction with fellow learners:
e-mail

# Data Acquisition and Control using LabVIEW

## Objectives

Software and hardware that we employ to measure the physical properties of processes that occur in the actual world are referred to as **"data acquisition"** . We use the word **"control"** to describe the act of altering particular characteristics in the physical environment. In order for computers to store and analyze real-world signals, we employ sensors to translate them into the electrical domain. In the actual world, actuators, motors, relays, etc. are used to regulate particular characteristics.

This module introduces the basic building blocks of a data acquisition system (DAS) and each block in detail. The module focuses on different sensor technologies used in production and logistics for automation. These fundamental aspects lead to smart sensors and actuators. The concept of automation, introduced using programmable logic controllers (PLCs), is introduced to the students.

**Professional competence:**

- Understanding the concept of data acquisition system
- Understanding the principles of different sensor technologies for automation
- Understanding the concepts of programming logic controller (PLC)

**Methodological competence:**

- Understand how microcontrollers can be used for data acquisition
- Understanding when to use wireless
- Understand the concept of industrial automation using a PLC.

**Personal competence:**

- Analysis and discussion of technical issues in production and operation of sensors and actuators
- Students learn what to focus on when evaluating or selecting a sensor
- Students learn limits and opportunities of various sensor interfaces (e.g. PWM) and various signal processing techniques

**Social competence:**

- Students are able to reflect on the requirements in the field of data acquisition systems and transfer them to relevant application scenarios.

## Entrance Requirements

Skillset Requirement:

- Basic knowledge of logical programming concepts.

## Learning Content

The student will explore the following concepts in **LabVIEW:**

- LabVIEW software working
- LabVIEW basics: Numericals | Booleans & comparators | Loops | Flat sequence
- Data handling instructions: Local and global variables | Strings | Matrix | File IO | Clusters | Waveform and wavechart
- Structures: Case structure | Event structure | Formula node

The student will explore the following concepts in **data acquisition and control:**

- Data acquisition system (DAS) | DAS components
- Sensor technologies classification & its characteristics
- Production and logistics sensors for automation
- Data and its classifications
- Signal conditioning: 3R's | Amplifier | Attenuation | Filtering | Isolation
- Digital signal processing: Signal sampling | Sample and hold | A/D and D/A conversion
- Wireless and grid-bound signal transmission
- Pulse width modulation (PWM) | H-bridge for actuators.
- Microcontroller: Ardunio
- Concepts of industrial automation using PLC.
- Statistics used in production and logistics

## Type of Examination

Portfolio

## Methods

- Lecture slides and handwritten notes: i-Learn (online learning platform)
- Programming examples in the lecture.
- Lab sessions and Interactive discussion
- Scientific research paper and seminar
- Programming assigments
- group project (2 to 3 students/group)

## Recommended Literature

Data Acquisition and Control handbook, first edition, keithley

LabVIEW manual by National instruments (NI), https://www.ni.com

Behzad Ehsani, "Data Acquisition using LabVIEW", Packt publishing Ltd., 2016

Joseph J. Carr, "Data Acquisition and Control: Micro-Computer Application for Scientists and Engineers", 1988

# Quality Management Methods & Tools

## Objectives

The module introduces students to the concept of quality management in engineering with the focus on statistical concepts, high end product quality, supplier quality and technical problem solving. On successful completion of this module, students should be able to understand quality management concepts, methods and tools especially in a technical and/or production environment.

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

**Professional competence:**

- understand and use statistical methods and concepts to monitor and improve production processes
- understand and use various methods to identify and eliminate technical problem root causes
- methods and concepts of quality management and quality assurance; use of AI in the field of quality

**Methodological competence:**

- understand and apply quality methods and tools to quality problems
- understand the overall concept of quality management ranging from statistics over organizational requirements up to quality standards and supplier/customer quality management

**Personal competence:**

- understand product quality as a long-term competitive advantage for companies, especially in the automotive market
- understanding and ability to use methods from different fields to improve and to monitor quality

**Social competence:**

- understand quality management as a company objective to support the customer
- ability to use various methods to achieve company quality targets

## Entrance Requirements

Mathematics on a bachelor of engineering graduate level.

## Learning Content

The following topics will be covered in class:
1. Statistical methods and probability
2. Capabilities
3. Statistical Process Control
4. Sub dpm Quality
5. Predictive Quality
6. Problem Solving
7. Supplier Quality Management
8. Standards & Certification

## Type of Examination

written ex. 90 min.

## Methods

seminar-style course with exercises

## Recommended Literature

Sondermann, J. P., QM, Beuth Hochschule für Technik Berlin, Fernstudieninstitut, TFH Berlin 2006, MBA Renewable Energies

Wittmann, J., Introduction to Quality Management in the Semiconductor Industry, Vol. 1: General, ISBN-10: 1535046341; ISBN-13: 978-1535046343), CreateSpace Independent Publishing Platform, Auflage 1, Aug 2016)

Brunner F. J. Brunner, K. W. Wagner, Qualitätsmanagement, Leitfaden für Studium und Praxis, 5. Auflage, Hanser, 2011

Linß, G. Qualitätsmanagement für Ingenieure, 2. Auflage, Fachbuchverlag Leipzig, 2005

Masing T. Pfeiffer, R. Schmitt, Masing Handbuch Qualitätsmanagement, Hanser, 6. Aufl.

Wittmann, J., The Safe Launch Concept, in Quality Management in Technology, 2019, Hrsg. J. Wittmann & W. Bergholz, Kindle , Direct Publishing

# MDM-13 Quality & Sustainability

| | |
|---|---|
| Module code | MDM-13 |
| Module coordination | Norbert Sosnowsky |
| Course number and name | MDM3101 Quality & Sustainability |
| Lecturer | Norbert Sosnowsky |
| Semester | 3 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 4 |
| ECTS | 5 |
| Workload | Time of attendance: 60 hours<br>self-study: 90 hours<br>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 module introduces students to the concept of sustainability in engineering with the focus on value, strategy, quality and controlling. On successful completion of this module, students should be able to understand and to analyze limitations of interdependent resources and company objectives. Students shall be able to evaluate and monitor the sustainability of technical systems and processes in production and logistics. They are familiar with the basic concepts of product life cycles, quality management and assurance, strategy development and execution and controlling.

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

**Professional competence:**

- sustainability and quality as basis of customer orientation and successful business management
- development of company value and strategy; different aspects of a sustainable company strategy
- methods and concepts of quality management and quality assurance; use of AI in the field of quality
- concepts and instruments of controlling; controlling of product and performance management

**Methodological competence:**

- develop strategy for specific topics or applications
- understand, define and implement controlling concepts, e.g. KPI dashboards
- understand and apply quality management methods, e.g. FMEA, FTA
- develop a sustainability concept for specific topics and applications

**Personal competence:**

- understand sustainability as a long-term competitive advantage for companies
- understanding and ability to use methods from different fields to improve and to monitor quality and sustainability

**Social competence:**

- Understand sustainability as complex entity. Ability to work on sub-topics towards the overall company and/or product sustainability.

## Applicability in this and other Programs

The module provides the necessary theoretical background and transfer possibility for sustainability, in particular different fields of knowledge contributing to it

Interfaces to mechatronics, production engineering and industrial engineering.

## Entrance Requirements

Bachelor degree in mechatronics, production engineering, industrial enginerring or a closely related field.

## Learning Content

The lecture provides insight into the importance values and strategy have for a company. The lecture covers:

- Importance, development and implementation of company values and company objectives
- Strategy development:

    - Vision and Mission
    - Objectives, Strategies and Policies
- Strategy implementation
- Strategy evaluation and control
- Strategic management and change management

The lecture also provides insight into the importance quality and controlling have for a company. It also provides knowledge of important methods and tools. The lecture covers:

- Statistical Process Control and Process Capability
- Quality Cost and Controlling
- Risk Assessment (FMEA, FTA)
- Problem Solving
- Definition and use of performance indicator systems
- Value oriented indicators
- Strategic and operative planning
- Gestaltung von Informationssystemen und Grundlagen zu Kennzahlen

## Teaching Methods

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

# MDM-14 Master Module

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|---|---|
| Module code | MDM-14 |
| Module coordination | Dr. Sunil Survaiya |
| Course number and name | MDM3102 Master Thesis<br>MDM3103 Master Colloquium |
| Lecturer | Dr. Sunil Survaiya |
| Semester | 3 |
| Duration of the module | 1 semester |
| Module frequency | each semester |
| Course type | required course |
| Level | postgraduate |
| Semester periods per week (SWS) | 2 |
| ECTS | 25 |
| Workload | Time of attendance: 30 hours<br>self-study: 720 hours<br>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 **" Applied AI for Digital Production Management"** 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 production and logistics management and the use of artificial intelligence in these fields.

The teaching content taught during the course of studies is applied in the form of a scientific paper. The problem is to be independently analyzed, 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 (23 ECTS), the Master's seminar (2 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 labor 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 (presentation and defence overall 40 minutes). The colloquium is assessed with 2 ECTS.

The Master's thesis may be written in German with the consent of the examination committee.

**Professional competence**

Students are enabled to familiarize 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 production and logistics management and the use of artificial intelligence in these fields in a scientifically sound manner.

**Methodological Competence**

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 **Applied AI for Digital Production Management** 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 30 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 favorable 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 recognized 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.