TECHNISCHE HOCHSCHULE DEGGENDORF

Module Guide
Applied AI for Digital Production Management

Faculty Applied Natural Sciences and Industrial Engineering
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Table of Contents

MDM-1 Machine Learning and Deep Learning in Production and Logistics

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	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5 out of 90 ECTS
Language of Instruction	English

Module Objective

Artificial Intelligence (AI) is a general term that describes the combination of all necessary methodological and technological tools needed for intelligent systems and applications. As part of AI Machine and Deep Learning are the main technologies being used in production and logistics.

In this course students are introduced to machine learning and deep learning as sub-fields of artificial intelligence. They are able to evaluate and select the best solution / approach regarding artificial intelligence for a specific application.

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

Professional competence:

- understanding machine learning as part of artificial intelligence
- understanding various methods of machine learning
- understanding modelling 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 teaches students how to solve complex tasks and problems in establishing and application of artificial intelligence in products and systems
- The students learn how to analyze and evaluate a problem and how to apply ML/DL technologies to solve it

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 Machine Learning and Deep Learning in Production and Logistics

The module provides the necessary theoretical knowledge and transfer possibility 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 applied to production and logistics topics. Correspondingly, this module presents a wide spectra of methods ranging from linear models to deep neural networks.

- Fundamentals: prognoses, correlation and causality
- Data collection, data processing and exploratory data analysis
- Operating principle of selected models:
    - linear regression including Maximum Likelihood Estimation, derivation of the error function and derivation of gradient descent
    - Feature Space: feature engineering and dimensional reduction (principal component analysis)
    - evaluation and tuning of models: selection of metrics, overfitting/ underfitting, optimisation of hyper parameters
    - Naive Bayes
    - decision trees
    - k-means clustering
- Neural Networks:
    - training with backpropagation
    - selection of a suitable architecture
    - comparison to other (traditional) models
    - efficient training on GPUs
- Applications in production and logistics

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

Thomas Dean, James Allen, Yiannis Aloimonos, "Artificial Intelligence: Theory and Practice", Addison Wesley

Stuart Russel, Peter Norvig, "Artificial Intelligence - a modern approach", Prentice Hall New Jersey

MDM-2 Advanced Statistical Methods & Optimization

Module code	MDM-2
Module coordination	Dr. Tim Weber
Course number and name	MDM1102 Advanced Statistical Methods & Optimization
Lecturer	Dr. Tim Weber
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5 out of 90 ECTS
Language of Instruction	German

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.

It is recommended that module MDM-01 Intelligent Systems is completed before taking this module.

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

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MDM-3 Data Management

Module code	MDM-3
Module coordination	Sebastian Grundstein
Course number and name	MDM1103 Production Data Management MDM1104 Application Systems - ERP & MES
Lecturer	Sebastian Grundstein
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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

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	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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)

MDM-5 Digital Tools in Development and Production

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	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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:

- Factory automation and Industrial Robotics
- Technology and digital implementation of additive manufacturing
- Setup, operation and application of VR/AR in production and logistics

Upon 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; selection and programming of industrial robots
- know the most important technologies and production processes as well as design and design digitalization regarding additive manufacturing
- 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 production and operation
- students learn what to focus on when evaluating or using methods and tools in production/logistics planning
- 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
- Device-related and physiological fundamentals, techniques and limitations
- 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
- 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

MDM-6 Case Study "AI project"

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	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weight	5 out of 90 ECTS
Language of Instruction	English

Module Objective

The case study **"AI projects"** takes up current case examples related to use of AI in production and logistics. Furthermore, students are given the 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 technical problem solving along a professional AI project handling path.

Upon completion of this module, depending on a more theoretical or more practical focus, students will be able to identify limitations and opportunities of the execution of AI projects in production and logistics.

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 including project planning, execution and results validation

Methodological competence:

- Students are able to execute a literature search in a specific AI, production or logistics related subarea
- Students are able to evaluate and assess methods for the selected specific fields of application

Personal competence:

- Case Study AI projects teaches students how to solve complex tasks in teams with distributed task areas. The students learn to analyse, synthesise and evaluate a task in relation to the execution of AI projects 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 questions in the area of AI in production and logistics 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 the transfer capability to gain a deeper understanding of AI methods in production and logistics and the respective AI project execution and for a specific area of application. 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 be chosen from any subject area of Machine Learning and Deep Learning in Production & Logistics, Advanced Statistical Methods

& Optimisation, Data Management and Production Data Management (Acquisition and Control).
The main aim is to get to know techniques available and to test these techniques. In addition, it should be understood where the limits and what the possibilities of ML/DL are in compared to conventional optimisation methods.
The topics of the case studies can vary each semester.

Teaching Methods

- Literature research
- Simulations
- Construction
- Programming
- Application of evaluation techniques
- Guided work on seminar topics in working groups. Accompanying events / presentations by external speakers depending on the selected topic area

MDM-7 Technology and Innovation Management

Module code	MDM-7
Module coordination	Sebastian Grundstein
Course number and name	MDM2101 Technology and Innovation Management
Lecturer	Sebastian Grundstein
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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
- know methods to initiate a 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
- they are able to create a business model for a startup

Personal competence:

- analysis and discussion of technical issues in technology and innovation management
- students learn what to focus on when evaluating new technologies and innovations

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 **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
- Start up
  - Business Idea
  - Business Plan
  - Core Team
  - Execution Timing
  - Market Research
  - Competitor Analysis
  - Product Development
  - Business Model

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-8 Advanced Intelligent Systems

Module code	MDM-8
Module coordination	Dr. Tim Weber
Course number and name	MDM2102 Big Data Processing & Analytics MDM2103 Natural Language Processing
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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 ?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. Contents are e.g.

- Sentiment Analysis
- Named Entity Recognition
- Summarization
- Topic Modeling
- Text Classification
- Keyword Extraction
- Lemmatization and stemming

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

MDM-9 Case Study Intelligent Systems in Production

Module code	MDM-9
Module coordination	Dr. Tim Weber
Course number and name	MDM2104 Case Study Intelligent Systems in Production
Lecturer	Dr. Sunil Survaiya
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weight	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 outcomes:

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	Sebastian Grundstein
Course number and name	MDM2105 Cyber-physical production systems & Smart Factory MDM2106 Simulation of Production Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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, e.g. time-discrete or agent-based. 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 outcomes:

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 capture data, energy and material flows in production systems or extract them from an ERP System; they know production simulation concepts

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, e.g. by using AnyLogic, Open modellica, Digital Twins

Personal competence:

- the students are able to implement their own methods and approaches and can argue against competing methods

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 Systems (CPS)

- Big Data-Technology and -infrastructure
- Cloud Computing in Production
- Production communication technology (e.g. Bluetooth, RFID, WLAN, 5G) and IoT
- Embedded Systems for production monitoring and control and for data processing
- Production and automation systems

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

- Agent based modeling
- System Dynamics modeling
- Discrete-event modeling
- Pedestrian modeling

with AnyLogic, Open Modelica or other suitable software.

Teaching Methods

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

Recommended Literature

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-11 Case Study Production Systems

Module code	MDM-11
Module coordination	Sebastian Grundstein
Course number and name	MDM2107 Case Study Production Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Portfolio
Weight	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

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

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.

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 be chosen from any subject area.

The topics of the case studies can vary each semester.

Teaching Methods

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

Remarks

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

The theoretical knowledge acquired by the students is specifically applied in practice in the case study topics so that students 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) ERP Systems and Digital Transformation Integrated Production Systems
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weight	5 out of 90 ECTS
Language of Instruction	German, 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.

- Product Innovation Management in Emerging Markets
- Computer Networking and Secure Network Management Interactive Online (CNSM)
- ERP Systems and Digital TransformationData Security and Data Protection (Master Medical Informatics)

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

ERP Systems and Digital Transformation

Objectives

Enterprise Resource Planning Systems (ERP systems) are part of the basic equipment of medium-sized companies and global corporations. In the operational environment they are the central application systems for controlling operational processes. As the central control unit and memory of every company, ERP systems support the operational work processes and, among other things, take over the integration task across all departments, from sales and procurement to production and accounting.
The digital transformation is changing work processes and forms of organization (see VDI 2013), which means that companies need to change their competence profiles (Gerholz 2018). Studies indicate that the ability to solve problems in the environment of operational processes and the central application systems (ERP systems), the understanding of new technologies (including the use of IoT, cloud computing, and AI) and monitoring activities

(e.g., analysis of the operational databases resulting from the processes; data analytics) are important (IW 2016).
This CLASSIC vhb course addresses these needs and introduces the central, operational application systems (ERP systems). After a theoretical introduction to the topic "ERP Systems" and "Business Processes", the learning environment offers participants the opportunity to deepen their knowledge of two ERP systems (Infor VISUAL ERP and Microsoft Dynamics NAV) and to consolidate the theoretical foundations through practical experience. In the subsequent case studies **"IoT"** , **"Mobile ERP"** , and **"Data Extraction"** , participants are given the opportunity to delve into current key topics in the field of business digitization processes. As an integrating data hub, ERP systems are the central starting point for implementing these digital trends.
Internet of Things (IoT) offers the technical basis in the production environment to connect machines and material digitally with the business application systems without media discontinuity. With the IoT infrastructure, planning-relevant machine data such as machine running times, downtimes, and rejects can be automatically reported directly from the shop floor up to the strategic planning systems (ERP system). The planning process is further optimized using current and accurate data points. In the case study, Microsoft Azure and a Raspberry simulator are used as basic components to penetrate the basic architecture of IoT solutions.
Mobile ERP is the application of an ERP system on mobile devices such as tablets and mobile phones. This type of application allows data to be created and retrieved in real time regardless of the company's location. In this way, for example, customer requirements can be better met. Ultimately, this leads to an improvement in the flow of information and to an optimization of the process flows. In the case study, the participant gains experience in the application and function of mobile ERP solutions using Microsoft Dynamics NAV as an example.
Data Extraction is the basis of any digitalized system. The exchange and provision of data even across company boundaries and the evaluation of this data by data analysis tools such as Power BI, Qlik, or Tableau form the technical basis of Business Intelligence projects. The case study uses PowerBI to develop basic concepts for connectivity and data presentation.

After successful completion of the module the learner should be able to ...

- identify structural characteristics and functionalities of ERP systems and compare individual ERP systems with each other based on these,
- recognize the integration effect of ERP systems and their architecture,
- assign digital task managers to operational tasks in a targeted manner,
- describe the potential of mobile ERP applications (Mobile ERP),
- describe and implement a basic architecture for the integration of sensor data into an ERP system in the context of the Internet of Things (IoT), and
- know and apply the possibility of data extraction and evaluation in the ERP environment as the basis of Business Intelligence (BI) software.

Learning Content

- Introduction to the field of ERP systems - LEA's DREAM: From industrialization to digitalization
- ERP basic knowledge - THEORY
- ERP application - INFOR VISUAL ERP
- ERP application - MICROSOFT DYNAMICS NAV
- Case study: IOT
- Case study: MOBILE ERP
- Case Study: DATA EXTRACTION

Type of Examination

written student research project

Methods

virtual lecture

Study work consisting of a practical elaboration in the ERP system including documentation (50 %) and case studies (50 %); further information on the exam can be found in the course environment.

Integrated Production Systems

Objectives

Participants of this course receive an overview of the tasks of a production manager in an international company:

- Motivation, philosophy, and objectives
- Methods and tools
- Experiences from industrial practice
- Overview of the current situation in terms of production systems of global acting companies

After having completed the course **'Integrated Production Systems'** students

- understand the essential characteristics of the Lean Concept,
- know and interiorized the meaning of the existing Lean Principles,
- understand the principles and objectives of the continuous process of improvement and are able to apply the most important corresponding methods and techniques,

- understand the difference between technology- and process-orientated production,
- know the reasons for as well as possible structures and main principles of global production and corresponding supply chains,
- comprehend principles and goals of the TQM approach and are able to apply the most important corresponding methods and techniques,
- understand the Jidoka principle and resulting potential benefits,
- understand and are able to apply the TPM concept together with its eight pillars,
- comprehend and are able to quantify the material and energy flows of manufacturing companies as well as influencing factors,
- understand the meaning of information in production processes,
- know the terminology and the essentials of Lean Development and Lean Administration.

Learning Content

1 Historical derivation, definition, and fundamental terms of traditional and integrated production systems (Taylorism and its realization by Henry Ford); critical analysis of the classical methods of division of responsibilities/work; Lean Production as a solution approach for the problems demonstrated
2 Description of basic pillars of integrated production systems (continuous process of improvement, Total Quality Management, value stream method, flow principle, the role of employees in the context of Lean Management)
3 Methods und tools of the continuous process of improvement: Ishikawa diagram, Pareto Analysis, A3 report, 5-W
4 Process-oriented production: differentiation to technology-orientated production, description of the key elements of flow-orientated production: Kanban, Just in Time, One Piece Flow, Heijunka
5 Global production networks in the context of Supply Chain Management: fundamentals of Supply Chain Management, supply chain structures, supply chain strategies
6 Fundamentals, elements, and tools of Total Quality Management (TQM): client orientation in the light of globalization, staff retention und assistance, risks associated with the implementation of TQM, Overall Equipment Efficiency (OEE) as a measuring instrument
7 Jidoka and Low Cost Automation (LCA): explanation of the Jidoka principle and associated tools (Poka Yoke, Andon), description of the LCA philosophy (five-levels concept), guidelines and checklists for the introduction of LCA systems

8 Total Productive Maintenance (TPM): description of seven steps for the realization of TPM, overview of TPM tools: Makigami, value stream method etc., transfer of the TPM concept into practice
9 Material and energy efficiency: measurement methods for the determination of consumptions, strategies for consumption reduction, methods for tapping the potentials of energy savings in practice, transfer of the Lean Concept to the energy value stream
10 Transfer of the Lean Concept to information provision and distribution, CAD/ CAM methods, Product Lifecycle Management (PLM), Enterprise Resource Planning (ERP)
11 Lean Development: introduction to product development according to the Lean Concept, methods and tools supporting the product development process, outcome measurement instruments
12 Lean Administration: transfer of the Lean Methods to administrative and management processes, identification of administrative processes and corresponding wastage rates
13 Repetition of the contents and preparation of the written exam

Type of Examination

written ex. 90 min.

Methods

- Lectures for download (English) and additional videos
- Online forum for discussion (English and German)
- Contact with the course tutor via phone and/or email (English and German)
- Interactive online portal for exercise questions (English and German)
- List of downloadable additional literature for gaining deeper insights (English)

MDM-13 Quality & Sustainability

Module code	MDM-13
Module coordination	Norbert Sosnowsky
Course number and name	MDM3101 Quality & Sustainability
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	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

Module code	MDM-14
Module coordination	Dr. Sunil Survaiya
Course number and name	MDM3102 Master thesis MDM3103 Master colloquium
Semester	3
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	2
ECTS	25
Workload	Time of attendance: 30 hours self-study: 720 hours Total: 750 hours
Type of Examination	colloquium, master thesis
Weight	5 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

Admission requirements are the successfully completed case studies including the scientific elaboration of the project topics.

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.