MODULE HANDBOOK

Master of Science

Master Artificial Intelligence (FS-FI-MAAI-60-01)

60 ECTS

Distance Learning and myStudies

INTERNATIONAL
UNIVERSITY OF
APPLIED SCIENCES

Contents

2023-02-01

1. Semester

Machine Learning

Module Code: DLMDSML

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSPWP01	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Thomas Zöller (Machine Learning)

Contributing Courses to Module

- Machine Learning (DLMDSML01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Exam, 90 Minutes Study Format: Distance Learning Exam, 90 Minutes	

Weight of Module

see curriculum

Module Contents

- Supervised, unsupervised, and reinforcement learning approaches
- Regression and classification learning problems
- Estimation of functional dependencies via regression techniques
- Data clustering
- Support vector machines, large margin classification
- Decision tree learning

Learning Outcomes

Machine Learning

On successful completion, students will be able to

- know different machine learning model classes.
- comprehend the difference between supervised, unsupervised, and reinforcement learning methods.
- understand common machine learning models.
- analyze trade-offs in the application of different models.
- appropriately choose machine learning models according to a given task.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Machine Learning

Course Code: DLMDSML01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01, DLMDSPWP01

Course Description

Machine learning is a field of scientific study concerned with algorithmic techniques that enable machines to learn performance on a given task via the discovery of patterns or regularities in exemplary data. Consequently, its methods commonly draw upon a statistical basis in conjunction with the computational capabilities of modern computing hardware. This course aims to acquaint the student with the main branches of machine learning and provide a thorough introduction to the most widely used approaches and methods in this field.

Course Outcomes

On successful completion, students will be able to

- know different machine learning model classes.
- comprehend the difference between supervised, unsupervised, and reinforcement learning methods.
- understand common machine learning models.
- analyze trade-offs in the application of different models.
- appropriately choose machine learning models according to a given task.

Contents

1. Introduction to Machine Learning
   - 1.1 Regression & Classification
   - 1.2 Supervised & Unsupervised Learning
   - 1.3 Reinforcement Learning
2. Clustering
   - 2.1 Introduction to clustering
   - 2.2 K-Means
   - 2.3 Expectation Maximization
   - 2.4 DBScan
   - 2.5 Hierarchical Clustering

3. Regression
   - 3.1 Linear & Non-linear Regression
   - 3.2 Logistic Regression
   - 3.3 Quantile Regression
   - 3.4 Multivariate Regression
   - 3.5 Lasso & Ridge Regression

4. Support Vector Machines
   - 4.1 Introduction to Support Vector Machines
   - 4.2 SVM for Classification
   - 4.3 SVM for Regression

5. Decision Trees
   - 5.1 Introduction to Decision Trees
   - 5.2 Decision Trees for Classification
   - 5.3 Decision Trees for Regression

6. Genetic Algorithms
   - 6.1 Introduction to Genetic Algorithms
   - 6.2 Applications of Genetic Algorithms

Literature

Compulsory Reading

Further Reading

- Akerkar, R., & Sajja, P. S. (2016). Intelligent techniques for data science. Springer International Publishing.
- Hodeghatta, U. R., & Nayak, U. (2017). Business analytics using R- A practical approach. Apress Publishing.
- Lahoz-Beltra, R. (2016). SGA: Simple Genetic Algorithm (SGA) in Python.
- Runkler, T. A. (2012). Data analytics: Models and algorithms for intelligent data analysis. Springer Vieweg Press.
- Skiena, S. S (2017). The data science design manual. Springer International Publishing. Database: Springer eBook Package English Computer Science.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Deep Learning

Module Code: DLMDSDL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSPWP01, DLMDSML01	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Thomas Zöller (Deep Learning)

Contributing Courses to Module

- Deep Learning (DLMDSDL01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Oral Assignment Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

- Introduction to neural networks and deep earning
- Network architectures
- Neural network training
- Alternative training methods
- Further network architectures

Learning Outcomes

Deep Learning

On successful completion, students will be able to

- comprehend the fundamental building blocks of neural networks.
- understand concepts in deep learning.
- analyze the relevant deep learning architecture in a wide range of application scenarios.
- create deep learning models.
- utilize alternative methods to train deep learning models.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Deep Learning

Course Code: DLMDSDL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01, DLMDSPWP01, DLMDSML01

Course Description

Neural networks and deep learning approaches have revolutionized the fields of data science and artificial intelligence in recent years, and applications built on these techniques have reached or surpassed human performance in many specialized applications.After a short review of the origins of neural networks and deep learning, this course will cover the most common neural network architectures and discuss in detail how neural networks are trained using dedicated data samples, avoiding common pitfalls such as overtraining.The course includes a detailed overview of alternative methods to train neural networks and further network architectures which are relevant in a wide range of specialized application scenarios.

Course Outcomes

On successful completion, students will be able to

- comprehend the fundamental building blocks of neural networks.
- understand concepts in deep learning.
- analyze the relevant deep learning architecture in a wide range of application scenarios.
- create deep learning models.
- utilize alternative methods to train deep learning models.

Contents

1. Introduction to Neural Network and Deep Learning
   - 1.1 The Biological Brain
   - 1.2 Perceptron and Multi-Layer Perceptrons
2. Network Architectures
   - 2.1 Feed-Forward Networks
   - 2.2 Convolutional Networks
   - 2.3 Recurrent Networks, Memory Cells and LSTMs
3. Neural Network Training
   - 3.1 Weight Initialization and Transfer Function
   - 3.2 Backpropagation and Gradient Descent
   - 3.3 Regularization and Overtraining

4. Alternative Training Methods
   - 4.1 Attention
   - 4.2 Feedback Alignment
   - 4.3 Synthetic Gradients
   - 4.4 Decoupled Network Interfaces

5. Further Network Architectures
   - 5.1 Generative Adversarial Networks
   - 5.2 Autoencoders
   - 5.3 Restricted Boltzmann Machines
   - 5.4 Capsule Networks
   - 5.5 Spiking Networks

Literature

Compulsory Reading

Further Reading

- Chollet, F. (2017). Deep learning with Python. Shelter Island, NY: Manning.
- Efron, B., & Hastie, T. (2016). Computer age statistical inference. Cambridge: Cambridge University Press.
- Geron, A. (2017). Hands-on machine learning with Scikit-Learn and TensorFlow. Boston, MA: O'Reilly Publishing.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. Boston, MA: MIT Press.
- Russel, S., & Norvig, P. (2010). Artificial intelligence – A modern approach (3rd ed.). Essex: Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
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Use Case and Evaluation

Module Code: DLMDSUCE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (Use Case and Evaluation)

Contributing Courses to Module

- Use Case and Evaluation (DLMDSUCE01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Oral Assignment Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

- Use case evaluation
- Model-centric evaluation
- Business-centric evaluation
- Monitoring
- Avoiding common fallacies
- Change management

Learning Outcomes

Use Case and Evaluation

On successful completion, students will be able to

- analyze use cases and their requirements regarding the project objectives.
- apply common metrics to evaluate predictions.
- evaluate key performance indicators to assess projects from a business perspective.
- create monitoring tools that can be used to constantly evaluate the status quo of a project.
- understand common fallacies and how to avoid them.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programms in the IT & Technology fields

Use Case and Evaluation

Course Code: DLMDSUCE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

The evaluation and definition of use cases is the fundamental groundwork from which the projects can be defined. This does not only include the scope and technical requirements of a project but also how value can be derived from the project. A crucial aspect is the definition of what makes a project successful, both in terms of a technical evaluation as well as a business centric perspective and how the status quo can be monitored effectively during the progress of a project. The course also discusses how to avoid common fallacies and understand the implications of introducing data-driven decisions into traditional management structures.

Course Outcomes

On successful completion, students will be able to

- analyze use cases and their requirements regarding the project objectives.
- apply common metrics to evaluate predictions.
- evaluate key performance indicators to assess projects from a business perspective.
- create monitoring tools that can be used to constantly evaluate the status quo of a project.
- understand common fallacies and how to avoid them.

Contents

1. Use Case Evaluation
   - 1.1 Identification of Use Cases
   - 1.2 Specifying Use Case Requirements
   - 1.3 Data Sources and Data Handling Classification
2. Model-centric Evaluation
   - 2.1 Common Metrics for Regression and Classification
   - 2.2 Visual Aides
3. Business-centric Evaluation
   - 3.1 Cost Function and Optimal Point Estimators
   - 3.2 Evaluation Using KPIs
   - 3.3 A/B Test

4. Monitoring
   - 4.1 Visual Monitoring Using Dashboards
   - 4.2 Automated Reporting and Alerting

5. Avoiding Common Fallacies
   - 5.1 Cognitive Biases
   - 5.2 Statistical Effects
   - 5.3 Change Management: Transformation to a Data-driven Company

Literature

Compulsory Reading

Further Reading

- Few, S. (2013). Information dashboard design: Displaying data for at-a-glance monitoring (2nd ed.). Burlingame, CA: Analytics Press.
- Gilliland, M., Tashman, L., & Sglavo, U. (2016). Business forecasting: Practical problems and solutions. Hoboken, NJ: John Wiley & Sons.
- Hyndman, R. (2018). Forecasting: Principles and practices (2nd ed.). Melbourne: OTexts.
- Kahneman, D. (2012). Thinking, fast and slow. New York, NY: Penguin Books.
- Osterwalder, A., & Pigneur, Y. (2010). Business model generation. Hoboken, NJ: Wiley.
- Parmenter, D. (2015). Key performance indicators: Developing, implementing, and using winning KPIs. Hoboken, NJ: John Wiley & Sons.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Reinforcement Learning

Module Code: DLMAIRIL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM, DLMDSPWP, DLMDSML, DLMDSDL	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (Reinforcement Learning)

Contributing Courses to Module

- Reinforcement Learning (DLMAIRIL01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Written Assessment: Written Assignment Study Format: Distance Learning Written Assessment: Written Assignment	

Weight of Module

see curriculum

Module Contents

- Introduction to reinforcement learning
- Markov chains
- Bandit
- Q-Learning
- Reinforcement learning approaches

Learning Outcomes

Reinforcement Learning

On successful completion, students will be able to

- understand the concepts of reinforcement learning.
- analyze Markov decision processes.
- evaluate value functions, actions and policies.
- apply Q-Learning methods to reinforcement learning problems.
- summarize model-free and model-based approaches.
- evaluate the tradeoff between exploitation and exploration.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Reinforcement Learning

Course Code: DLMAIRIL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM, DLMDSPWP, DLMDSML, DLMDSDL

Course Description

Reinforcement learning allows computers to derive problem-solving strategies without being explicitly programmed for the specific task, similar to the way humans and animals learn.After introducing the concepts of reinforcement learning, the course discusses the properties of Markov chains and single- and multi-armed bandits in detail. Special attention is given to the understanding of value functions and discounted value functions.The course connects reinforcement learning with neural networks and deep learning and discusses how Q-Learning approaches can be used to utilize deep learning methods in reinforcement learning problems, including extensions such as double Q-Learning, hierarchical learning, and actor-critic learning.Finally, the course discusses reinforcement learning approaches such as model-free and model-based learning and the tradeoff between exploration and exploitation.

Course Outcomes

On successful completion, students will be able to

- understand the concepts of reinforcement learning.
- analyze Markov decision processes.
- evaluate value functions, actions and policies.
- apply Q-Learning methods to reinforcement learning problems.
- summarize model-free and model-based approaches.
- evaluate the tradeoff between exploitation and exploration.

Contents

1. Introduction to Reinforcement Learning
   - 1.1 Understanding Reinforcement Learning
   - 1.2 Components of Reinforcement Learning Systems

2. Markov Chains
   - 2.1 Markov Decision Process & Markov Property
   - 2.2 Value Functions and Discounted Value Functions
   - 2.3 General Utility Function
   - 2.4 Actions & Policy
   - 2.5 Bellman's Equation
   - 2.6 Value Iteration
   - 2.7 Markov Chain Monte Carlo (MCMC)

3. Bandit
   - 3.1 Single-Arm Bandit
   - 3.2 Multi-Arm Bandit

4. Q-Learning
   - 4.1 Time-difference Learning
   - 4.2 Reinforcement Learning with Neural Networks & Deep Q Learning
   - 4.3 Experience Replay
   - 4.4 Double Q-Learning
   - 4.5 Delayed Sparse Rewards
   - 4.6 Hierarchical Learning
   - 4.7 Value- vs Policy-Based Learning
   - 4.8 Actor Critic Learning

5. Reinforcement Learning Approaches
   - 5.1 Model-Free Learning
   - 5.2 Model-Based Learning
   - 5.3 Exploration vs Exploitation

Literature

Compulsory Reading

Further Reading

- Bertsekas, D. P. (2019). Reinforcement learning and optimal control. Athena Scientific
- Sutton, R. S., & Barto, A. G. (1998). Reinforcement learning: An introduction. MIT Press.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Seminar: Current Topics in AI

Module Code: DLMAISCTAI

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Tim Schlippe (Seminar: Current Topics in AI)

Contributing Courses to Module

- Seminar: Current Topics in AI (DLMAISCTAI01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Written Assessment: Research Essay Study Format: Distance Learning Written Assessment: Research Essay	

Weight of Module

see curriculum

Module Contents

In this module, students will reflect on current developments in AI. To this end, pertinent topics will be introduced via articles that are then critically evaluated by the students in the form of a written essay.

Learning Outcomes

Seminar: Current Topics in AI

On successful completion, students will be able to

- discuss current research trends and topics in AI.
- compose a theoretical essay exploring a selected topic in AI.
- expound upon apposite assumptions and design choices pertaining to the topic of choice.
- link the chosen topic to analogous approaches.
- identify and delineate potential uses for the chosen topic's concepts.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Seminar: Current Topics in AI

Course Code: DLMAISCTAI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

The topic of artificial Intelligence (AI) has been addressed in computer science and cognitive science research since the 1950s; however, the meaning associated with the term has changed considerably over time. Having once been predominantly associated with logical calculus, reasoning, and planning, AI is now primarily interpreted in the context of deep networks of computational units. Despite these changes in approach, the important characteristic of AI continues to be the understanding and reproduction of cognitive abilities and functions by machines. This seminar strives to elucidate current research trends in AI. The students learn to independently analyze selected topics and case studies and link them with well-known concepts, as well as critically question and discuss them.

Course Outcomes

On successful completion, students will be able to

- discuss current research trends and topics in AI.
- compose a theoretical essay exploring a selected topic in AI.
- expound upon apposite assumptions and design choices pertaining to the topic of choice.
- link the chosen topic to analogous approaches.
- identify and delineate potential uses for the chosen topic's concepts.

Contents

- The seminar covers current topics in artificial intelligence. Each participant must write a seminar paper on a topic assigned to him/her.

Literature

Compulsory Reading

Further Reading

- Turabian, K. L. (2013). A manual for writers of research papers, theses, and dissertations. Chicago: University of Chicago Press.
- Swales, J. M., & Feak, C. R. (2012). Academic writing for graduate students, essential tasks and skills. Michigan: University of Michigan Press.
- Bailey, S. (2011). Academic writing for international students of business. New York, NY: Routledge

Study Format myStudies

Study Format	Course Type
myStudies	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☑ Slides
☐ Exam Template	

Project: AI Use Case

Module Code: DLMAIPAIUC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM, DLMDSUCE	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Tim Schlippe (Project: AI Use Case)

Contributing Courses to Module

- Project: AI Use Case (DLMAIPAIUC01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Portfolio Study Format: Distance Learning Portfolio	

Weight of Module

see curriculum

Module Contents

A current list of topics is given in the Learning Management System. This forms the basis of the course but can be amended or updated by the tutor.

Learning Outcomes

Project: AI Use Case

On successful completion, students will be able to

- apply the concepts covered in the preceding artificial intelligence (AI) courses to build a running AI model or system.
- explain the design choices made in the selection of the employed model and its implementation.
- transfer acquired theoretical knowledge to real-world case studies.
- translate the learned theories into the practice of AI system building.
- critically evaluate the resulting model's or system's performance.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Project: AI Use Case

Course Code: DLMAIPAIUC01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM, DLMDSUCE

Course Description

In the course “Project: AI Use Case”, students choose a project task in accord with their tutor from a variety of options. The goal is to prototypically implement an artificial intelligence model or system in a suitable development environment. The choice of approach, the system or software implemented, and the resulting performance on the task are to be reasoned about, explained, and documented in a project report. To this end, students make practical use of the methodological knowledge acquired in the previous courses by applying them to relevant real-world problems.

Course Outcomes

On successful completion, students will be able to

- apply the concepts covered in the preceding artificial intelligence (AI) courses to build a running AI model or system.
- explain the design choices made in the selection of the employed model and its implementation.
- transfer acquired theoretical knowledge to real-world case studies.
- translate the learned theories into the practice of AI system building.
- critically evaluate the resulting model’s or system’s performance.

Contents

- In this project course the students work on a practical implementation of an artificial intelligence use case of their choosing. All relevant artifacts like use case evaluation, chosen implementation method, code, and outcomes are to be documented in the form of a written project report.

Literature
Compulsory Reading
Further Reading ▪ Jackson, P. (1998). Introduction to expert systems (3rd. ed.). Chicago, IL: Addison Wesley Longman. ▪ Nilsson, N. (2009). The quest for artificial intelligence. Cambridge: Cambridge University Press. ▪ Russel, S., & Norvig, P. (2009). Artificial intelligence: A modern approach (3rd ed.). Malaysia: Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
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☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
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☐ Vodcast	☑ Guideline
☐ Shortcast	☑ Live Tutorium/Course Feed
☐ Audio	☑ Slides
☐ Exam Template	

2. Semester

Inference and Causality

Module Code: DLMAIIAC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM, DLMDSAS, DLMDSPWP	MA	5	150 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (Inference and Causality)

Contributing Courses to Module

- Inference and Causality (DLMAIIAC01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Advanced Workbook Study Format: Distance Learning Advanced Workbook	

Weight of Module

see curriculum

Module Contents

- Statistical inference
- Introduction to causality
- Interventions
- Do-calculus
- Fallacies

Learning Outcomes

Inference and Causality

On successful completion, students will be able to

- examine data in terms of statistical inference.
- create probabilistic models.
- understand the building blocks of causal inference.
- analyze interventions in statistical systems.
- follow the rules of do-calculus.
- evaluate common fallacies in causal analysis.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Inference and Causality

Course Code: DLMAIIAC01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM, DLMDSAS, DLMDSPWP

Course Description

Statistical inference and causal analysis are crucial tools for analyzing and understanding data on a fundamental level. This course starts with an introduction to Bayesian inference and Bayesian networks which use probabilities to describe statistical problems and introduce probabilistic modelling which allows the specification of Bayesian statistical models in code. This course introduces the concepts of causality, how causality relates to correlation between variables, and discusses the fundamental building blocks of causal analysis. The effect of interventions (i.e., when the experimenter actively changes the setup from which the data are taken) are also discussed. This course then introduces the rules of do-calculus, which allow interventions to be described formally.Finally, the course discusses a wide range of typical fallacies which arise in the context of causal analysis.

Course Outcomes

On successful completion, students will be able to

- examine data in terms of statistical inference.
- create probabilistic models.
- understand the building blocks of causal inference.
- analyze interventions in statistical systems.
- follow the rules of do-calculus.
- evaluate common fallacies in causal analysis.

Contents

1. Statistical Inference
   - 1.1 Bayesian inference
   - 1.2 Bayesian networks
   - 1.3 Probabilistic modelling
2. Introduction to Causality
   - 2.1 Correlation vs causation
   - 2.2 Granger causality
   - 2.3 Directed Acyclic Graphs (DAG)
   - 2.4 Elements of causal graphs: collider, chain, fork
   - 2.5 D – separation

3. Interventions
   - 3.1 Seeing vs doing
   - 3.2 Conditional independence
   - 3.3 Confounders & counterfactuals
   - 3.4 Causal inference vs randomized controlled trials

4. Do-calculus
   - 4.1 Front- & backdoor criterion
   - 4.2 Three rules of do-calculus

5. Fallacies
   - 5.1 Mediation fallacy
   - 5.2 Collider bias
   - 5.3 Simpson's & Berkson's Paradox
   - 5.4 Imputing missing values: causal vs data-driven view

Literature

Compulsory Reading

Further Reading

- Berzuini, C., Dawid, P., & Bernardinelli, L. (2012). Causality: Statistical perspectives and applications. Wiley.
- Hernan, M. A., & Robins, J. M. (2020). Causal inference: What if. CRC Press.
- Pearl, J. (2013). Causality: Models, reasoning and inference (2nd ed.). Cambridge University Press.
- Pearl, J., & Mackenzie, D. (2018). The book of why: The new science of cause and effect. Basic Books.
- Pearl, J., Glymour, M., & Jewell, N. P. (2016). Causal inference in statistics: A primer. Wiley.
- Wakefield, J. (2013). Bayesian and frequentist regression methods. Springer.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Computer Vision and NLP

Module Code: DLMAIECVN

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSAM, DLMDSPWP, DLMDSML, DLMAINLPCV01 ▪ DLMDSAM, DLMDSPWP, DLMDSML	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

N.N Professur für Computer Vision (NLP and Computer Vision) / N.N. Professur für Computer Vision (Advanced NLP and Computer Vision)

Contributing Courses to Module

- NLP and Computer Vision (DLMAINLPCV01)
- Advanced NLP and Computer Vision (DLMAIEAIS01)

Module Exam Type	
Module Exam	**Split Exam** NLP and Computer Vision • Study Format "Distance Learning": Oral Assignment • Study Format "myStudies": Oral Assignment Advanced NLP and Computer Vision • Study Format "Distance Learning": Exam, 90 Minutes

Weight of Module
see curriculum

Module Contents

NLP and Computer Vision

- Important methods in computer vision and NLP
- Relevant applications in both domains
- Security and privacy implications of computer vision and NLP

Advanced NLP and Computer Vision

- Machine translation and semantic text interpretation
- Recovery of scene geometry
- Semantic image and video analysis
- Object tracking

Learning Outcomes

NLP and Computer Vision

On successful completion, students will be able to

- name important problems in natural language and image processing.
- recognize the common algorithms and methods to address said problems.
- understand common use-case scenarios in which NLP and computer vision techniques are applied.
- analyze the advantages and drawbacks of various NLP and computer vision algorithms.
- reflect on pertinent implications of NLP and computer vision technology with respect to privacy and security.

Advanced NLP and Computer Vision

On successful completion, students will be able to

- name core aspects of advanced computer vision and NLP problems and techniques.
- summarize current approaches to problems in text and speech processing.
- recognize promising developments in scene understanding and semantic image analysis.
- remember challenges and solution strategies in single and multiple object tracking.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

NLP and Computer Vision

Course Code: DLMAINLPCV01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM, DLMDSPWP, DLMDSML

Course Description

This course elucidates contemporary approaches to computer vision and natural language processing. In order to achieve this goal, two problem domains are introduced with a comprehensive overview on related topics and techniques. It is then demonstrated how related tasks arise in relevant application scenarios. Finally, an outlook on privacy and security aspects is provided in order to sensitize the students to pressing questions in this domain.

Course Outcomes

On successful completion, students will be able to

- name important problems in natural language and image processing.
- recognize the common algorithms and methods to address said problems.
- understand common use-case scenarios in which NLP and computer vision techniques are applied.
- analyze the advantages and drawbacks of various NLP and computer vision algorithms.
- reflect on pertinent implications of NLP and computer vision technology with respect to privacy and security.

Contents

1. Introduction to NLP
   - 1.1 What is NLP?
   - 1.2 Regular expressions, tokenization & stop-words
   - 1.3 Bag of Words and word vectors
   - 1.4 N-Grams: Grouping related words
   - 1.5 Word sense disambiguation
   - 1.6 NLP with Python
2. Applications of NLP
   - 2.1 Topic identification and text summary
   - 2.2 Sentiment analysis
   - 2.3 Named entity recognition
   - 2.4 Translation
   - 2.5 Chatbots

3. Introduction to Computer Vision
   - 3.1 What is computer vision?
   - 3.2 Pixels and filters
   - 3.3 Feature detection
   - 3.4 Distortion and calibration
   - 3.5 Multiple & stereo vision
   - 3.6 Computer vision with Python

4. Applications of Computer Vision
   - 4.1 Image classification, motion tracking
   - 4.2 Semantic segmentation
   - 4.3 Object identification & tracking
   - 4.4 Eigenfaces and facial recognition

5. Privacy and Security
   - 5.1 Adversarial image attacks
   - 5.2 Privacy of visual data & privacy preserving visual features
   - 5.3 Wearable and mobile camera privacy

Literature

Compulsory Reading

Further Reading

- Bird S., Klein, E., & Loper, E. (2009). Natural language processing with Python. O'Reilly.
- Fisher, R. B., Breckon, T. P., Dawson-Howe, K., Fitzgibbon, A. , Robertson, C. , Trucco, E., & Williams, C. K. I. (2014). Dictionary of computer vision and image processing. Wiley .

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Advanced NLP and Computer Vision

Course Code: DLMAIEAIS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM, DLMDSPWP, DLMDSML, DLMAINLPCV01

Course Description

This course expands upon the material presented in the introductory NLP and Computer Vision course. With respect to the processing of text, it provides an overview of machine translation and information extraction. Moreover, it addresses signal processing aspects of NLP such as speech recognition and synthesis. Additionally, important concepts from the subject domain of computer vision such as the recovery of scene geometry, the semantic analysis of still and video imagery, and object tracking are discussed.

Course Outcomes

On successful completion, students will be able to

- name core aspects of advanced computer vision and NLP problems and techniques.
- summarize current approaches to problems in text and speech processing.
- recognize promising developments in scene understanding and semantic image analysis.
- remember challenges and solution strategies in single and multiple object tracking.

Contents

1. Text Processing
   - 1.1 Machine translation
   - 1.2 Information extraction
2. Speech Signal Processing
   - 2.1 Speech recognition
   - 2.2 Speech synthesis
3. Geometry Reconstruction
   - 3.1 3D reconstruction from 2D images/videos
   - 3.2 Change of perspective

4. Semantic Image Analysis
   - 4.1 Image retrieval
   - 4.2 Semantic segmentation / object detection
   - 4.3 Medical imaging analysis
   - 4.4 Copyright violation, counterfeit and forgery detection
   - 4.5 Face recognition and biometrics

5. Tracking
   - 5.1 Challenges in tracking
   - 5.2 Object representation
   - 5.3 Single vs. multiple object tracking

Literature

Compulsory Reading

Further Reading

- Bengfort, B., Bilbro, R., & Ojeda, T. (2018). Applied text analysis with Python: Enabling language aware data products with machine learning. O'Reilly.
- Clark, A., Fox, C., & Lappin, S. (Eds.). (2010). The handbook of computational linguistics and natural language processing. Wiley-Blackwell.
- Davies, E. R. (2017). Computer vision: Principles, algorithms, applications, learning (5th ed.). Academic Press.
- Fisher, R. B., Breckon, T. P., Dawson-Howe, K., Fitzgibbon, A., Robertson, C., Trucco, E., & Williams, C. K. I. (2016). Dictionary of computer vision and image processing (2nd ed.). Wiley.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Advanced Robotics 4.0

Module Code: DLMAIEAR

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMAIEAR01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimaldauer: 1 Semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Leonardo Riccardi (Industrial and Mobile Robots) / Prof. Dr. Leonardo Riccardi (Project: Collaborative Robotics)

Contributing Courses to Module

- Industrial and Mobile Robots (DLMAIEAR01)
- Project: Collaborative Robotics (DLMAIEAR02)

Module Exam Type

Module Exam	Split Exam
	Industrial and Mobile Robots • Study Format "Distance Learning": Exam, 90 Minutes Project: Collaborative Robotics • Study Format "Distance Learning": Written Assessment: Project Report

Weight of Module

see curriculum

Module Contents

Industrial and Mobile Robots

- Architectural components of mobile and industrial robots
- Mathematical description
- Design of interactions and control

Project: Collaborative Robotics

- Human-robot interaction
- Safety operation
- Human-friendly robot design

A current list of topics is located in the Learning Management System.

Learning Outcomes

Industrial and Mobile Robots

On successful completion, students will be able to

- identify the main challenges of robotics in the era of Industry 4.0.
- understand the working principles of industrial and mobile robots.
- model a robotic system and design a motion control algorithm.
- use software platforms to command the execution of tasks and retrieve the execution status.

Project: Collaborative Robotics

On successful completion, students will be able to

- classify interactions between robots and humans.
- identify safety and risk scenarios.
- understand the principles of human-friendly robot design.
- apply algorithms for safe interaction.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Engineering.	All Master Programs in the IT & Technology field.

Industrial and Mobile Robots

Course Code: DLMAIEAR01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

The focus of this course is the theoretical foundation of mobile and industrial robotics. First, the basic concepts, architectural components (e.g., actuators and sensors), and challenges related to mobile and industrial robotics in the era of Industry 4.0 are presented. Next, the mathematical aspects concerning robot kinematics and trajectory planning are considered. These are necessary in order to define the operative task that a robot (mobile or industrial) must execute. The dynamics of a robotic system provides a mathematical model of the robot which can be exploited for simulation, design, and to control the task execution. There are various control architectures and approaches for robotic systems. This course focuses on the centralized and de-centralized architectures, as well as simple control design (e.g., proportional-integral-derivative control approaches).Finally, this course introduces the main software platforms and architectures used to control and exchange data with robots in a multi-agent environment, for instance, a manufacturing facility where many robots execute different tasks or must cooperate. The main patterns of such architectures and their uses are discussed. The adoption of model-based sensing/perception and control approaches yields intelligent systems which interact with the environment. This course concludes with an overview of behavior-based robotics, where robots are able to dynamically react to and learn from the real world.

Course Outcomes

On successful completion, students will be able to

- identify the main challenges of robotics in the era of Industry 4.0.
- understand the working principles of industrial and mobile robots.
- model a robotic system and design a motion control algorithm.
- use software platforms to command the execution of tasks and retrieve the execution status.

Contents

1. Introduction
   - 1.1 Robots and manufacturing
   - 1.2 Industrial robots
   - 1.3 Mobile robots
   - 1.4 Actuators for robotics
   - 1.5 Trends in robotics

2. Kinematics
   - 2.1 Position and orientation of a rigid body
   - 2.2 Joint kinematics
   - 2.3 Forward kinematics
   - 2.4 Inverse kinematics
   - 2.5 Differential kinematics
   - 2.6 Kinematics of mobile robots

3. Trajectory Planning
   - 3.1 Basic concepts
   - 3.2 Trajectories in the joints space
   - 3.3 Trajectories in the workspace
   - 3.4 Trajectory planning for mobile robots

4. Sensing and Perception
   - 4.1 Position
   - 4.2 Velocity
   - 4.3 Force
   - 4.4 Distance
   - 4.5 Visual

5. Fundamentals of Robot Dynamics
   - 5.1 Rigid body dynamics
   - 5.2 Lagrange formulation
   - 5.3 Newton formulation
   - 5.4 Direct and inverse dynamics
   - 5.5 Dynamics of mobile robots

6. Control of Robots
   - 6.1 Basic concepts
   - 6.2 Decentralized motion control
   - 6.3 Centralized motion control
   - 6.4 Force control

7. Architecture of Robotic Systems
   - 7.1 Architectural components
   - 7.2 Open Robot Control Software (OROCOS)
   - 7.3 Yet Another Robotic System Platform (YARP)
   - 7.4 Robot Operating System (ROS)
   - 7.5 Behavior-based robotics

Literature

Compulsory Reading

Further Reading

- Ben-Ari, M., & Mondada, F. (2017). Elements of robotics. Springer International Publishing.
- Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2009). Robotics. Springer.
- Siciliano, B., & Khatib, O. (Eds.). (2016). Springer handbook of robotics (2nd ed.). Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Project: Collaborative Robotics

Course Code: DLMAIEAR02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMAIEAR01

Course Description

A collaborative robot is a robot which is used in collaborative operation, where humans and robots share the same workspace. This course focuses on the basic concepts of collaborative robotics, such as classification of human-robot interaction, definition of safe interaction, soft robotics and human-friendly robot design, and algorithms to guarantee such a safe interaction. The students will receive a hands-on introduction to the topic, with the goal of being able to autonomously design, simulate and test collaborative robotic systems.

Course Outcomes

On successful completion, students will be able to

- classify interactions between robots and humans.
- identify safety and risk scenarios.
- understand the principles of human-friendly robot design.
- apply algorithms for safe interaction.

Contents

- Each participant must create a project report on a topic related to collaborative robotics, focusing on design and/or implementation aspects.

Literature

Compulsory Reading

Further Reading

- Ben-Ari, M., & Mondada, F. (2018). Elements of robotics. Cham: Springer.
- Corke, P. (2017). Robotics, vision and control (2nd ed.). Berlin, Heidelberg: Springer.
- Mihelj, M., Bajd, T., Ude, A., Lenarčič, J., Stanovnik, A., Munih, M., ... Šlajpah, S. (2019). Robotics (2nd ed.). Cham: Springer.
- Siciliano, B., & Khatib, O. (Eds.). (2016). Springer handbook of robotics (2nd ed.). Berlin, Heidelberg: Springer.
- Teixeira, J. V. S., Reis, A. M., Mendes, F. B., & Vergara, L. G. L. (2019). Collaborative Robots. In P. Arezes (Ed.), Occupational and environmental safety and health. Studies in systems, decision and control (pp. 791-796). Cham: Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Artificial Intelligence in FinTech

Module Code: DLMAIEFT

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEFT01 ▪ none	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Muhammad Ashfaq (Concepts of FinTechs and Artificial Intelligence) / Prof. Dr. Muhammad Ashfaq (Fraud Detection FinTechs)

Contributing Courses to Module

- Concepts of FinTechs and Artificial Intelligence (DLMAIEFT01)
- Fraud Detection FinTechs (DLMAIEFT02)

Module Exam Type

Module Exam	Split Exam
	Concepts of FinTechs and Artificial Intelligence • Study Format "Distance Learning": Exam or Written Assessment: Written Assignment, 90 Minutes Fraud Detection FinTechs • Study Format "Distance Learning": Written Assessment: Case Study

Weight of Module

see curriculum

Module Contents

Concepts of FinTechs and Artificial Intelligence

- Introduction of FinTechs and AI
- Application of FinTechs in banking and finance
- FinTech and AI underlying Technologies
- AI Application in the financial services industry
- Trust and ethical issues related to AI and FinTech
- Future of FinTech and AI

Fraud Detection FinTechs

- Introduction of Fraud detections FinTechs
- Insurance Fraud
- Money Laundering
- Identity Fraud
- Key application areas of AI Anomaly Detection in financial institutions
- Challenges of AI use in Fraud detection in financial institutions

Learning Outcomes

Concepts of FinTechs and Artificial Intelligence

On successful completion, students will be able to

- understand definitions of FinTech, AI and gain an overview of the FinTech ecosystem and factors of the financial revolution.
- identify different applications of FinTechs in the banking industry such as retail, investment and wealth management.
- learn about key underlying technologies that are shaping the financial revolution by exploring blockchain, Distributed Leader Technology, smart contracts and machine learning.
- learn how AI is supporting financial institutions in areas such as deposits, lending, Know Your Customer (KYC), Anti-Money Laundering (AML) and credit scorecard models.
- critically evaluate different issues related to AI and FinTech such as lack of trust and transparency, data protection and sustainable financing.
- develop a solid understanding of the future of banking, cryptocurrencies and CBDCs.

Fraud Detection FinTechs

On successful completion, students will be able to

- recognize the importance of fraud detection in FinTechs by exploring recent frauds such as Wirecard.
- analyze examples of FinTech and AI companies that are identifying and preventing frauds.
- describe different types of insurance frauds and assess how advanced analytics can help identification of frauds.
- learn how AI can be used in cross-border transactions to detect money laundering and assess the viability of various tools such as machine learning and Regtech.
- critically evaluate how financial institutions are using AI in lending, asset management and protection of personal identity.
- outline challenges of application of AI such as quality of data, shortage of qualified staff, implementation of technology and regulatory issues.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Finance & Tax Accounting.	All Master Programs in the Business & Management field.

Concepts of FinTechs and Artificial Intelligence

Course Code: DLMAIEFT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

There has been an unprecedented level of advancement in technology during the last two decades which impacts all segments of the economy particularly caused a revolution in the financial services industry. Incumbent financial institutions lag in innovative solutions to changing customer needs and are facing a great deal of competition as well as collaboration opportunities from an army of FinTech and AI-based start-ups. In Europe, these start-ups emerged due to open banking regulations and neobanks are challenging established banks' bricks-and-mortar business model. The Covid-19 pandemic has further accelerated the growth of FinTech companies that offer agile, transparent, efficient, cost-effective and innovative solutions to tech-savvy customers in areas such as cross-border payments, online purchases, wealth management and lending – just to mention a few. Thus, FinTechs are transforming financial institutions using technologies such as AI, data analytics and blockchain. Students will have a comprehensive overview of FinTech and AI, learn about the FinTech ecosystem, open banking regulation in Europe, contemporary developments in banking technologies and practical application of FinTech and AI.This course aims to critically discuss the contemporary issues related to FinTech and AI such as regulatory reforms, creativity and innovation challenges, customer data protection, ethical issues and green tech financing. Students will also discuss the future of applications of FinTech and AI in banking and finance and critically evaluate the evolution of cryptocurrencies and central bank digital currencies. This course also provides students an opportunity to debate and discuss how big Tech companies are shaping the finance world, what lessons can be learned from past crises, the future of branch banking, and what impact FinTech and AI starts can make on financing ESG and sustainable projects.

Course Outcomes

On successful completion, students will be able to

- understand definitions of FinTech, AI and gain an overview of the FinTech ecosystem and factors of the financial revolution.
- identify different applications of FinTechs in the banking industry such as retail, investment and wealth management.
- learn about key underlying technologies that are shaping the financial revolution by exploring blockchain, Distributed Leader Technology, smart contracts and machine learning.
- learn how AI is supporting financial institutions in areas such as deposits, lending, Know Your Customer (KYC), Anti-Money Laundering (AML) and credit scorecard models.
- critically evaluate different issues related to AI and FinTech such as lack of trust and transparency, data protection and sustainable financing.
- develop a solid understanding of the future of banking, cryptocurrencies and CBDCs.

Contents

1. Introduction of FinTechs and AI
   - 1.1 Definition of FinTechs and AI
   - 1.2 FinTech Ecosystem
   - 1.3 Revolution in the Financial Services Industry
   - 1.4 Open Banking Regulation

2. Application of FinTechs in Banking and Finance
   - 2.1 Retail Banking
   - 2.2 Payment Transactions
   - 2.3 Wealth Management
   - 2.4 Financing
   - 2.5 Scope of FinTech in Financial Inclusion

3. FinTech and AI Underlying Technologies
   - 3.1 Contemporary Developments in Banking Technology
   - 3.2 Cloud Banking
   - 3.3 Blockchain and DLT and Smart Contracts
   - 3.4 Machine and Deep Learning
   - 3.5 Neuroscience in Finance

4. AI Application in the Financial Services industry
   - 4.1 AI in Deposits and Lending
   - 4.2 Chatbots in Banking
   - 4.3 AI USe in Developing Credit Scoring Models
   - 4.4 AI in the Insurance Sector
   - 4.5 KYC and AML

5. Trust and Ethical Issues Related to AI and FinTech
   - 5.1 Biasness and AI Algorithmic Discrimination
   - 5.2 GDPR Directive in Europe
   - 5.3 Contemporary Regulatory Landscapes in Other Jurisdictions

6. Future of FinTech and AI
   - 6.1 Building Trust from Past Events
   - 6.2 New Collaboration Opportunities
   - 6.3 Future of Banking Technology
   - 6.4 Role of FinTech and AI Start-ups in Sustainable and ESG Financing
   - 6.5 Future of Banking, Cryptocurrencies and CBDCs

Literature

Compulsory Reading

Further Reading

- Arjundwadkar, P.Y. (2018) FinTech: the technology driving disruption in the financial services industry. CRC Press (Taylor & Francis Group), London.
- Chishti, S., Bartoletti, I., Leslie, A. & Millie, S.M. (2020). The AI book: the Artificial Intelligence handbook for investors, Entrepreneurs and FinTech visionaries. Wiley, West Sussex.
- Lui, A. & Ryder, N. (2021). FinTech, Artificial Intelligence and the law: regulation and crime prevention. Routledge, London.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam or Written Assessment: Written Assignment, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Fraud Detection FinTechs

Course Code: DLMAIEFT02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEFT01

Course Description

The financial services industry has been burgeoning over the last five decades, however, factors such as globalization, use of smartphones, increase in bandwidth, sophistication in technology, mobile banking and tech-savvy customers have paved the way for Financial Technology (FinTech) companies that are challenging incumbent financial institutions by offering fast, cost-effective and efficient solutions. But, as growth in FinTech companies and online business activities is sky-rocketing, various types of frauds are also increasing. Merchantsavvy, a payment comparison website stated that in 2020 the global losses that occurred due to payment fraud amounted to USD 32 billion and it includes theft of money, stealing personal property and personal data. Financial frauds have peaked during the Covid-19 pandemic as a large number of people use online channels to conduct their financial activities such as cross-border payments, investments and retail banking. Advancements in cutting-edge technologies such as machine learning, AI and algorithms are helping financial institutions to detect and prevent anomalies in transactions. Credit card frauds represent one of the important segments of fraud used by fraudulent but banks are rushing to implement two-factor authentication. Financial institutions are under immense pressure to beef up their compliance and meet increasing regulatory requirements particularly in the area of Anti-money Laundry (AML). AI-based solutions offer fast and efficient detection of frauds in a cost-effective manner which otherwise requires huge human capabilities. Banks are processing billions of transactions every month and facing the challenge of KYC as most of the customers are moving to digital accounts. This course aims to help students to explore how AI can help to detect frauds in FinTechs and also in traditional financial institutions at an early stage and how it can prevent them. Students will study different use cases, case studies and examples to enrich their knowledge.

Course Outcomes

On successful completion, students will be able to

- recognize the importance of fraud detection in FinTechs by exploring recent frauds such as Wirecard.
- analyze examples of FinTech and AI companies that are identifying and preventing frauds.
- describe different types of insurance frauds and assess how advanced analytics can help identification of frauds.
- learn how AI can be used in cross-border transactions to detect money laundering and assess the viability of various tools such as machine learning and Regtech.
- critically evaluate how financial institutions are using AI in lending, asset management and protection of personal identity.
- outline challenges of application of AI such as quality of data, shortage of qualified staff, implementation of technology and regulatory issues.

Contents

1. Introduction of Fraud Detections FinTechs
   - 1.1 The Exponential Growth of FinTechs
   - 1.2 Importance of Fraud Detection and Prevention in FinTechs
   - 1.3 Wirecard FinTech Fraud in Germany
   - 1.4 Examples of FinTech Companies Detecting Fraud
2. Insurance Fraud
   - 2.1 Nature of Insurance Frauds
   - 2.2 Application of Advanced Analytics for Fraud Detection
   - 2.3 Case Studies such as the OneConnect Smart Insurance Platform
3. Money Laundering
   - 3.1 Overview of Cross-board Payments
   - 3.2 AI Use in Crypto-assets Fraud Detection
   - 3.3 Regtech and Machine Learning for Fraud Detection
   - 3.4 Regulatory Fines and Case Studies (HSBC, BNP Paribas)
4. Identity Fraud
   - 4.1 Fraud of Personal Data
   - 4.2 Fraud Detection in Account Opening Process
   - 4.3 Accounts and Transaction Frauds

5. Key Application Areas of AI Anomaly Detection in Financial Institutions
   - 5.1 Lending
   - 5.2 Asset management
   - 5.3 Payments
   - 5.4 AI and Predictive Analytics

6. Key Challenges of AI Use in Fraud Detection in Financial Institutions
   - 6.1 Quality of Data
   - 6.2 Lack of Qualified Staff
   - 6.3 Regulatory Issues
   - 6.4 Implementation of Technology such as Biometrics
   - 6.5 Regulatory Fines and Case Studies (HSBC, BNP Paribas)

Literature

Compulsory Reading

Further Reading

- Arslanian, H. and Fischer, F. (2019). The future of finance: the impact of FinTech, AI, and crypto on financial services. Palgrave Macmillan, Cham.
- Ashfaq, M. and Randall, V.J. (2020). Wirecard: The rise and fall of a German FinTech, The Case Centre, UK.
- Boobier, T. (2020). AI and the future of banking. John Wiley & Sons Ltd, West Sussex.
- Gough, L. (2021). The CON men: a history of financial fraud and the lessons you can learn. Pearson, Harlow.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Applied Autonomous Driving

Module Code: DLMDSEAAD

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Dr. Benjamin Lehmann (Architectures of Self-Driving Vehicles) / Dr. Benjamin Lehmann (Case Study: Localization, Motion Planning and Sensor Fusion)

Contributing Courses to Module

- Architectures of Self-Driving Vehicles (DLMDSEAAD01)
- Case Study: Localization, Motion Planning and Sensor Fusion (DLMDSEAAD02)

Module Exam Type

Module Exam	Split Exam
	Architectures of Self-Driving Vehicles • Study Format "Distance Learning": Exam, 90 Minutes Case Study: Localization, Motion Planning and Sensor Fusion • Study Format "Distance Learning": Written Assessment: Case Study

Weight of Module

see curriculum

Module Contents

Architectures of Self-Driving Vehicles

- Architectural patterns of a self-driving car
- Perception and motion control
- Social impact of autonomous vehicles

Case Study: Localization, Motion Planning and Sensor Fusion

- Algorithms for localization and navigation
- Sensor fusion methods for localization and objects tracking
- Motion planning algorithms

Learning Outcomes

Architectures of Self-Driving Vehicles

On successful completion, students will be able to

- explain and recognize the main components of a self-driving car.
- distinguish the sensor solutions for a self-driving car and adopt the best one for a given scenario.
- model and implement a simple motion control system.
- manage the main communication protocols to retrieve valuable information.
- reflect on the social impact of self-driving cars.

Case Study: Localization, Motion Planning and Sensor Fusion

On successful completion, students will be able to

- distinguish the methods used for localization, motion planning, and sensor fusion.
- apply the methods to autonomous vehicles.
- understand the main issues related to the adoption of autonomous vehicles in real-world scenarios.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Engineering	All Master Programmes in the IT & Technology fields

Architectures of Self-Driving Vehicles

Course Code: DLMDSEAAD01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

This course gives an overview of the main architectural aspects of a self-driving car. After introducing the hardware and software platforms, the course presents the sensor solutions necessary to provide environment perception for autonomous vehicles. Such perception yields the information used for motion control, including braking and steering. The fundamental concepts for the realization and implementation of motion control are presented, together with related safety issues (e.g., motion control under false information). The way in which a self-driving car exchanges information with the outside world is also discussed, and the main technologies and protocols are introduced. The last part of the course elaborates on the social impact of self-driving cars: ethics, mobility, and design.

Course Outcomes

On successful completion, students will be able to

- explain and recognize the main components of a self-driving car.
- distinguish the sensor solutions for a self-driving car and adopt the best one for a given scenario.
- model and implement a simple motion control system.
- manage the main communication protocols to retrieve valuable information.
- reflect on the social impact of self-driving cars.

Contents

1. Introduction
    - 1.1 Basic concepts and key technologies
    - 1.2 Hardware overview
    - 1.3 Software overview
    - 1.4 State of the art and open challenges
    - 1.5 Trends

2. Environment Perception
   - 2.1 Basic concepts
   - 2.2 GPS
   - 2.3 Inertial sensors
   - 2.4 Lidar and Radar
   - 2.5 Cameras

3. Moving, Braking, Steering
   - 3.1 Fundamentals
   - 3.2 Dynamics of a mobile vehicle
   - 3.3 Braking technologies
   - 3.4 Lateral and longitudinal control
   - 3.5 Safety issues

4. Communication
   - 4.1 Car2X communication
   - 4.2 Protocols
   - 4.3 Safety issues

5. Social Impact
   - 5.1 Ethics for autonomous vehicles
   - 5.2 New mobility
   - 5.3 Autonomous vehicles and design

Literature

Compulsory Reading

Further Reading

- Heinrichs, D. (2016). Autonomous driving and urban land use. In M. Maurer, J. Gerdes, B. Lenz, H. Winner (Eds.) Autonomous driving (pp. 213—231). Springer.
- Mueck, M., & Karls, I. (2018). Networking vehicles to everything: Evolving automotive solutions. Walter de Gruyter GmbH & Co KG.
- Schaub, A. (2018). Robust perception from optical sensors for reactive behaviors in autonomous robotic vehicles. Springer.
- Sjafrie, H. (2019). Introduction to self-driving vehicle technology. CRC Press.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Case Study: Localization, Motion Planning and Sensor Fusion

Course Code: DLMDSEAAD02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

This course provides the fundamental concepts and methods of localization, motion planning, and sensor fusion for mobile robotics and self-driving cars. Mobile robots and autonomous vehicles rely on the ability to perceive the environment and react to its dynamic changes.The first part of the course focuses on the representation of motion and navigation based on odometry, which is affected by errors due to information uncertainty. A possible solution is offered by localization methods which use odometry and complementary information, such as a GPS signal, to improve the estimation of the position of the autonomous vehicles within a reference frame. In this way, the vehicle is able to move towards a goal.The problems with detecting dynamic change in the environment is addressed in the last part of the course, where the methods of sensor fusion are introduced. Thanks to the fusion of multiple data sources, information can be extracted, e.g., an approaching object or a change in a situation can be revealed. The autonomous vehicle must be able to track the object and react to its movement to avoid human hazard and damage. The determination of the best trajectory to follow is addressed in the final part of the course.The course gives a hands-on overview of the main methods for localization, motion planning, and sensor fusion. The students must apply the concepts and methods to case studies involving a self-driving vehicle in two main scenarios: “on the road” and in a manufacturing facility.

Course Outcomes

On successful completion, students will be able to

- distinguish the methods used for localization, motion planning, and sensor fusion.
- apply the methods to autonomous vehicles.
- understand the main issues related to the adoption of autonomous vehicles in real-world scenarios.

Contents

Literature
Compulsory Reading
Further Reading ▪ Mitchell, H. B. (2007). Multi-sensor data fusion: An introduction. Springer. ▪ Siciliano, B., & Khatib, O. (Eds.). (2016). Springer handbook of robotics. Springer. ▪ Thrun, S. (2002). Probabilistic robotics. Communications of the ACM, 45(3), 52—57.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

DLMDSEAAD02

Artificial Intelligence in Supply Chain Management

Module Code: DLMAIESCM

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Amin Zitouni (Concepts of Artificial Intelligence in Supply Chain Management) / Prof. Dr. Amin Zitouni (Multi-Agent Systems)

Contributing Courses to Module

- Concepts of Artificial Intelligence in Supply Chain Management (DLMAIESCM01)
- Multi-Agent Systems (DLMAIESCM02)

Module Exam Type

Module Exam	Split Exam
	Concepts of Artificial Intelligence in Supply Chain Management • Study Format "Distance Learning": Written Assessment: Case Study Multi-Agent Systems • Study Format "Distance Learning": Written Assessment: Case Study

Weight of Module

see curriculum

Module Contents

Concepts of Artificial Intelligence in Supply Chain Management

- Fundamentals of Supply Chain Management
- Conceptional and mathematical introduction to key Artificial Intelligence disciplines for Supply Chains
- Models for improving transparency along Supply Chains
- Methods to support strategic and tactical decision-making in Supply Chains
- AI approaches for Supply Chain Operations
- Challenges of applying AI in Supply Chains

Multi-Agent Systems

- Concept of Agents and Multi-Agent systems
- Typology of intelligent Agents
- Agent communication and cooperation
- Multi-Agent Decision-Making
- Reinforcement Learning-Multi-Agent
- Potentials of Multi-Agent applications in Supply Chains

Learning Outcomes

Concepts of Artificial Intelligence in Supply Chain Management

On successful completion, students will be able to

- understand fundamental elements of Supply Chains and Supply Chain Management.
- describe different AI disciplines with relevance to Supply Chain Management.
- describe specific AI methods for strategic and tactical decision-making.
- evaluate AI concepts and their application fields for operational tasks in Supply Chains.
- understand important challenges of applying AI in Supply Chains.

Multi-Agent Systems

On successful completion, students will be able to

- give an overview of the fundamentals in Multi-Agent technology.
- understand relevant design principles for Multi-Agent Systems.
- design and build fundamental Multi-Agent systems.
- understand and apply common Multi-Agent decision-making strategies.
- evaluate benefits of Multi-Agent technology for various Supply Chain challenges.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Concepts of Artificial Intelligence in Supply Chain Management

Course Code: DLMAIESCM01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

With start of the 2020s the fragility of global supply chains and their relevance for economies down to individual consumers became transparent, as global production and transportation stopped for weeks due to the Covid-19 pandemic. Results of these broken supply chains were production stops and even some empty shelves in supermarkets. Consequently, the question arises as to how new technology fields such as artificial intelligence can contribute to more resilient, more effective, and yet efficient supply chains. This course begins by explaining the current understanding of supply chains and a possible future state of it: Supply Chains 4.0. Next, the most promising artificial intelligence disciplines are presented and discussed to address the outlined challenges in the supply chain. In this context, the course presents suitable AI concepts, methods, and specific models for several relevant fields of supply chain management, which are also applicable to a variety of supply chain topics and use cases. The focus is on transparency, decision-making and operations along supply chains. The course concludes by discussing specific challenges for implementing AI in supply chains.

Course Outcomes

On successful completion, students will be able to

- understand fundamental elements of Supply Chains and Supply Chain Management.
- describe different AI disciplines with relevance to Supply Chain Management.
- describe specific AI methods for strategic and tactical decision-making.
- evaluate AI concepts and their application fields for operational tasks in Supply Chains.
- understand important challenges of applying AI in Supply Chains.

Contents

1. Fundamentals of Supply Chain Management
   - 1.1 Concept of Supply Chain and Supply Network
   - 1.2 End-to-End View of Supply Chain Management
   - 1.3 The Vision of Supply Chain 4.0

2. Conceptional and Mathematical Introduction to Key Artificial Intelligence Disciplines for Supply Chains
   - 2.1 Conventional Techniques
   - 2.2 Machine Learning Algorithms
   - 2.3 Neural Networks
   - 2.4 Robot Process Automation
   - 2.5 Multi-Agent Systems

3. Models for improving transparency along Supply Chains
   - 3.1 Customer and Churn Analytics
   - 3.2 Order Peak time Prediction
   - 3.3 Risk and Fraud Detection
   - 3.4 Spend Analytics
   - 3.5 Defect Detection and Predictive Maintenance

4. Methods to Support Strategic and Tactical Decision-Making in Supply Chains
   - 4.1 Supply Chain Network Planning
   - 4.2 Supplier Selection
   - 4.3 Replenishment Strategies
   - 4.4 Route Optimization
   - 4.5 Sales & Operations Planning

5. AI Concepts in Supply Chain Operations
   - 5.1 Supplier Communication and Purchasing
   - 5.2 Autonomous Allocation of Orders to Production Resources
   - 5.3 Dynamic Routing
   - 5.4 Object Identification in Logistics

6. Challenges of applying AI in Supply Chains
   - 6.1 The Challenge of Trust
   - 6.2 The Challenges of Capability
   - 6.3 The Challenges of Accountability
   - 6.4 The Challenges of Accessibility
   - 6.5 The Challenges of Organizational Transformation

Literature

Compulsory Reading

Further Reading

- Chopra, S. (2019): Supply chain management. Strategy, planning, and operation. Pearson.
- Hwang, I. & Jang, Y. J. (2020): Q(λ) learning-based dynamic route guidance algorithm for overhead hoist transport systems in semiconductor fabs, International Journal of Production Research, 58:4, 1199-1221. DOI: 10.1080/00207543.2019.1614692
- Masrour, T., Cherrafi, A., El Hassani, I. (2021): Artificial Intelligence and Industrial Applications: Smart Operation Management, Springer
- Park, J.; Kim, M.-H.; Choi, D.-G. (2021): Correspondence Learning for Deep Multi-Modal Recognition and Fraud Detection. Electronics 2021, 10, 800. https://doi.org/10.3390/electronics10070800
- Selvakanmani, S., Pranamita, N., Deepak, K., Kavi, B.A., Salmaan, A.K. (2020): Churn prediction using ensemble learning: an analytical CRM application. Int. J. Adv. Sci. Technol. Vol. 29, No. 5, p. 9192–9200
- Triepels, R., Daniels, H., Feelders, A. (2019): Data-driven fraud detection in international shipping, Expert Systems With Applications 99, Elsevir, p.193-202.
- Wang, C. & Jiang, P (2019). Deep neural networks based order completion time prediction by using real-time job shop RFID data. Journal of Intelligent Manufacturing, Vol. 30, No. 3, p. 1303–1318.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Multi-Agent Systems

Course Code: DLMAIESCM02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

In the last decade artificial intelligence has made significant progress based on breakthroughs in machine learning techniques and their wide range of application. As a result, Machine learning has become a synonym for Artificial Intelligence. This course extends the view on A. I. by introducing Multi-Agent Systems, as one of the first A. I. related fields of research. The course starts with explaining why Multi-Agent Systems will become the foundation of the next level for more sophisticated applications of Artificial Intelligence. Understanding, designing, and building Multi-Agent Systems however follow specific design principles and fundamental approaches, which are explained and discussed in this course. The topic of autonomous and distributed decision making of Agents is key for the practical relevance of Multi-Agent technology, especially in the field of Supply Chains. In this context fundamental concepts of collaboration and negotiation in Multi-Agent Systems are presented. The course concludes with connecting the Multi-Agent technology with the concept of reinforcement learning.

Course Outcomes

On successful completion, students will be able to

- give an overview of the fundamentals in Multi-Agent technology.
- understand relevant design principles for Multi-Agent Systems.
- design and build fundamental Multi-Agent systems.
- understand and apply common Multi-Agent decision-making strategies.
- evaluate benefits of Multi-Agent technology for various Supply Chain challenges.

Contents

1. Agent technology
   - 1.1 Concept of Agents and Multi-Agent Systems
   - 1.2 Agent Applications
   - 1.3 Agents Oriented Design and Methodologies
2. Typology of Intelligent Agents
   - 2.1 Reasoning Agents
   - 2.2 Reactive Agents
   - 2.3 Hybrid Agents

3. Agent Communication
   - 3.1 Ontology
   - 3.2 Communication Languages

4. Agent Cooperation
   - 4.1 Distributed Problem Solving
   - 4.2 Task and Result Sharing
   - 4.3 Handling Inconsistency
   - 4.4 Planning and Synchronization

5. Multi-Agent Decision-Making
   - 5.1 Strategies
   - 5.2 Group Decisions
   - 5.3 Coalitions
   - 5.4 Bargaining
   - 5.5 Arguing

6. Reinforcement Learning-Multi-Agent
   - 6.1 The Goal of Reinforcement Learning
   - 6.2 Benefits and Challenge
   - 6.3 Introducing Multi-Agent Reinforcement Learning Algorithms

7. Potentials of Multi-Agent Applications in Supply Chains
   - 7.1 Multi-Agents Application for Strategic and Tactical Tasks
   - 7.2 Multi-Agents Application in Operational Processes
   - 7.3 Multi-Agents Embedded in Cyber-Physical Systems

Literature
Compulsory Reading
Further Reading ▪ Bellifemine, F. L., Caire, G., Greenwood, D. (2007): Developing Multi-Agent Systems with JADE. Wiley. ▪ Bordini, R. H., Dastani, M., Dix, J., El Fallah Seghrouchni, A. (2009): Multi-Agent Programming, Languages, Tools and Applications. Springer. ▪ Bordini, R., Hübner, & J. F., Wooldridge, M. (2007): Programming Multi-Agent Systems in AgentSpeak using Jason. Wiley. ▪ Paolucci M, Sacile R (2016) Agent-based manufacturing and control systems: new agile manufacturing solutions for achieving peak performance. CRC Press. ▪ Shoham, Y., & Leyton-Brown, K. (2009): Multiagent Systems, Algorithmic, Game-Theoretic, and Logical Foundations. Cambridge University Press. ▪ Uhrmacher, A. M., & Weyns, D. (2009): Multi-Agent Systems, Simulation and Applications. CRC Press. ▪ Weiss, G. (2013): Multiagent Systems, The MIT Press. Cambridge.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

AI in Healthcare and Medical Imaging

Module Code: DLMAIEHCMI

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (AI in Healthcare) / Prof. Dr. Ulrich Kerzel (AI in Medical Imaging and Diagnostics)

Contributing Courses to Module

- AI in Healthcare (DLMAIEHCMI01)
- AI in Medical Imaging and Diagnostics (DLMAIEHCMI02)

Module Exam Type

Module Exam	Split Exam
	AI in Healthcare • Study Format "Distance Learning": Exam, 90 Minutes AI in Medical Imaging and Diagnostics • Study Format "Distance Learning": Oral Assignment

Weight of Module
see curriculum

Module Contents

AI in Healthcare

- Healthcare Stakeholders
- Drug Discovery
- Personalized Care
- Blockchain in Healthcare
- Fraud Detection
- Regulations and Ethics

AI in Medical Imaging and Diagnostics

- Introduction to Medical Imaging and Diagnostics
- Medical Imaging Techniques
- Computer Vision Fundamentals
- Computer Vision with Deep Learning
- Applications of AI in Medical Imaging & Case Studies

Learning Outcomes

AI in Healthcare

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

AI in Medical Imaging and Diagnostics

On successful completion, students will be able to

- analyze the challenges of using artificial intelligence in medical imaging.
- understand the most common medical imaging techniques.
- apply artificial intelligence methods to medical imaging scenarios.
- create deep learning-based image analysis algorithms using medical images.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

AI in Healthcare

Course Code: DLMAIEHCMI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

The course gives an overview over a wide range of topics in which artificial intelligence has the potential to transform the way healthcare operates. The course starts with an introduction to the key stakeholders in healthcare. Afterwards, discovery of new drugs and medicines are discussed where artificial intelligence is already starting to make a big impact. Next, the topics personalized care, blockchain in healthcare and fraud detection are discussed which are key drivers in the digitalization of healthcare in the future. Finally, the course covers the foundations of regulations and ethics in healthcare with a strong focus on data driven methods and artificial intelligence, including data protection, bias in AI and explainable AI methods.

Course Outcomes

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

Contents

1. Healthcare Stakeholders
   - 1.1 Healthcare Management
   - 1.2 Insurance & Intermediaries
   - 1.3 Pre-Clinical & Clinical Care Providers
   - 1.4 GP & Specialist Care
   - 1.5 Industry (Pharma / Medical Products)
   - 1.6 Patents & Society
2. Drug Discovery
   - 2.1 Drug Discovery Approaches
   - 2.2 AI in Drug Discovery

3. Personalized Care
   - 3.1 Medication Monitoring
   - 3.2 Virtual Nursing Assistants

4. Blockchain in Healthcare
   - 4.1 Introduction to Blockchains & Medical Blockchains
   - 4.2 Blockchain in Organ Procurement
   - 4.3 Blockchain for Electronic Health Records (EHR)
   - 4.4 Blockchain for Pharma Supply Chain (Forged Drugs, etc)

5. Fraud Detection
   - 5.1 Introduction to Fraud Detection
   - 5.2 ICD-10 Codes
   - 5.3 Fraud Detection in Healthcare Management

6. Regulations and Ethics
   - 6.1 Legal & Regulatory Requirements
   - 6.2 Data Protection Foundations, GDPR
   - 6.3 Privacy in Machine Learning and AI
   - 6.4 Bias & Fairness in AI
   - 6.5 Explainable AI

Literature

Compulsory Reading

Further Reading

- Alleyn, T. et al (eds) (2020): Target Discovery and Validation: Methods and Strategies for Drug Discovery, Wiley.
- Antonopoulos, A. (2017): Mastering Bitcoin, 2nd ed. O'Reilley.
- Blass, B. (2015). Basic Principles of Drug Discovery and Development, Academic Press.
- Boccia, S. et al. (eds.) (2020): Personalised Health Care, Springer.
- Brown, N. (2020): Artificial Intelligence in Drug Discovery, Royal Society of Chemistry.
- Challen, R. et al. (2019). Artificial intelligence, bias and clinical safety. BMJ Quality & Safety, 28(3), 231-237.
- Costigliola, V. ed. (2012): Healthcare Overview: New Perspectives, Springer.
- Denton, B. (2013): Handbook of Healthcare Operations Management: Methods and Applications, Springer.
- Gupta, D. et al. (eds) (2020): Advanced Computational Intelligence Techniques for Virtual Reality in Healthcare, Springer.
- Hall, R. (ed) (2012): Handbook of Healthcare System Scheduling, Springer.
- IT Governance Privacy Team (2020): EU General Data Protection Regulation (GDPR) – An implementation and compliance guide, fourth edition, ITGP.
- Lantz, L., Cawrey, D. (2020): Mastering Blockchain, O'Reilley.
- Levine, A. et al. (eds) (2013) The Comprehensive Textbook of Healthcare Simulation, Springer.
- McCradden, M. D. et al. (2020). Patient safety and quality improvement: Ethical principles for a regulatory approach to bias in healthcare machine learning. Journal of the American Medical Informatics Association, 27(12), 2024-2027.
- Molnar, Ch. (2019), Interpretable Machine Learning, Lulu.
- O'Donnell, J. et al (eds.) (2021): Drug Discovery and Development, 3rd ed., CRC Press.
- Pinedo, M. (201): Scheduling: Theory, Algorithms, and Systems, 5th ed., Springer.
- Vissers, J. (2005): Health Operations Management.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

AI in Medical Imaging and Diagnostics

Course Code: DLMAIEHCMI02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01

Course Description

The course focuses on image based medical diagnostics. The course starts with a short review of the history of image-based diagnostics and then considers general aspects of using artificial intelligence in healthcare, such as issues concerning the relevant "ground truth" data to train AI models on, integration of artificial intelligence into clinical practice and explainable AI methods. Next, the fundamentals of imaging techniques are discussed, such as X-Ray and computer aided tomography, magnetic resonance imaging, positron emission tomography and ultrasound imaging. Following the image acquisition methods, the course then turns towards image analysis techniques, starting with the fundamentals of computer vision before turning towards deep learning-based approaches. Finally, the course discusses relevant case studies and application scenarios.

Course Outcomes

On successful completion, students will be able to

- analyze the challenges of using artificial intelligence in medical imaging.
- understand the most common medical imaging techniques.
- apply artificial intelligence methods to medical imaging scenarios.
- create deep learning-based image analysis algorithms using medical images.

Contents

1. Introduction to Medical Imaging and Diagnostics
   - 1.1 History of Image-Based Diagnostics
   - 1.2 Obtaining Ground-Truth Data
   - 1.3 Domain Expertise & Integration into Clinical Practice
   - 1.4 Explainability & Bias in Medical AI
2. Medical Imaging Techniques
   - 2.1 X-Ray and Computer Aided Tomography (CT)
   - 2.2 Magnetic Resonance Imaging (MRI)
   - 2.3 Positron Emission Tomography (PET)
   - 2.4 Ultrasound Imaging

3. Computer Vision Fundamentals
   - 3.1 Low Level Computer Vision
   - 3.2 Mid Level Computer Vision
   - 3.3 High Level Computer Vision

4. Computer Vision with Deep Learning
   - 4.1 Image Classification
   - 4.2 Object Detection
   - 4.3 Image Segmentation
   - 4.4 Further Topics

5. Applications of AI in Medical Imaging & Case Studies
   - 5.1 Disease Identification
   - 5.2 Image Acquisition
   - 5.3 Survival Prediction

Literature

Compulsory Reading

Further Reading

- Banerjee, I. et al. (2021): Reading Race: AI Recognizes Patient's Racial Identity In Medical Images, arXiv preprint https://arxiv.org/abs/2107.10356.
- Bushberg, J. et al (2020): The Essential Physics of Medical Imaging, 4th ed. Wolters Kluwer Health.
- Esteva, A. et al. Dermatologist-level classification of skin cancer with deep neural networks. Nature 542, 115–118 (2017). https://doi.org/10.1038/nature21056.
- Feeman, T. (2015): The Mathematics of Medical Imaging, 2nd ed., Springer.
- Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall.
- Geron, A. (2019), Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd ed., O'Reilley.
- Goodfellow et al (2016): Deep Learning, MIT Press.
- Molnar, Ch. (2019), Interpretable Machine Learning, Lulu.
- Oren, O. Gersh, B., Bhatt, D. (2020): Artificial intelligence in medical imaging: switching from radiographic pathological data to clinically meaningful endpoints, The Lancet, VOLUME 2, ISSUE 9, E486-E488, DOI: https://doi.org/10.1016/S2589-7500(20)30160-6 .
- Poldrack, R. et al (2011): Handbook of Functional MRI Data Analysis, Cambridge University Press.
- Roberts, M., Driggs, D., Thorpe, M. et al. (2021) Common pitfalls and recommendations for using machine learning to detect and prognosticate for COVID-19 using chest radiographs and CT scans. Nat Mach Intell 3, 199–217. https://doi.org/10.1038/s42256-021-00307-0.
- Smith, N., Webb, A. (2010): Introduction to Medical Imaging, Cambridge University Press.
- Stippich, Ch. (ed) (2021): Clinical Functional MRI, Springer.
- Szeliski,R. (2010):Computer Vision - Algorithms and Applications, Springer, 2010.
- Wang, S. et al (2016): Accelerating magnetic resonance imaging via deep learning, 2016 IEEE 13th International Symposium on Biomedical Imaging (ISBI).
- Wulczyn, E. et al (2021): Interpretable survival prediction for colorectal cancer using deep learning, npj Digit. Med. 4, 71, DOI: https://doi.org/10.1038/s41746-021-00427-2.
- Wynants, L. et al (2020), Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal, BMJ 2020;369:m1328.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

AI in Healthcare and Medical NLP

Module Code: DLMAIEHMNLP

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (AI in Healthcare) / Prof. Dr. Ulrich Kerzel (Medical NLP)

Contributing Courses to Module

- AI in Healthcare (DLMAIEHCMI01)
- Medical NLP (DLMAIEMNMR01)

Module Exam Type

Module Exam	Split Exam
	AI in Healthcare • Study Format "Distance Learning": Exam, 90 Minutes Medical NLP • Study Format "Distance Learning": Written Assessment: Written Assignment

Weight of Module
see curriculum

Module Contents

AI in Healthcare

- Healthcare Stakeholders
- Drug Discovery
- Personalized Care
- Blockchain in Healthcare
- Fraud Detection
- Regulations and Ethics

Medical NLP

- Introduction to NLP
- Language Modelling
- NLP with Deep Learning
- NLP Tasks
- Application Scenarios & Case Studies

Learning Outcomes

AI in Healthcare

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

Medical NLP

On successful completion, students will be able to

- understand the concepts of natural language processing.
- analyze texts with statistical models.
- create deep learning-based NLP models.
- evaluate which NLP method is appropriate for a specific application scenario.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

AI in Healthcare

Course Code: DLMAIEHCMI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

The course gives an overview over a wide range of topics in which artificial intelligence has the potential to transform the way healthcare operates. The course starts with an introduction to the key stakeholders in healthcare. Afterwards, discovery of new drugs and medicines are discussed where artificial intelligence is already starting to make a big impact. Next, the topics personalized care, blockchain in healthcare and fraud detection are discussed which are key drivers in the digitalization of healthcare in the future. Finally, the course covers the foundations of regulations and ethics in healthcare with a strong focus on data driven methods and artificial intelligence, including data protection, bias in AI and explainable AI methods.

Course Outcomes

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

Contents

1. Healthcare Stakeholders
   - 1.1 Healthcare Management
   - 1.2 Insurance & Intermediaries
   - 1.3 Pre-Clinical & Clinical Care Providers
   - 1.4 GP & Specialist Care
   - 1.5 Industry (Pharma / Medical Products)
   - 1.6 Patents & Society
2. Drug Discovery
   - 2.1 Drug Discovery Approaches
   - 2.2 AI in Drug Discovery

3. Personalized Care
   - 3.1 Medication Monitoring
   - 3.2 Virtual Nursing Assistants

4. Blockchain in Healthcare
   - 4.1 Introduction to Blockchains & Medical Blockchains
   - 4.2 Blockchain in Organ Procurement
   - 4.3 Blockchain for Electronic Health Records (EHR)
   - 4.4 Blockchain for Pharma Supply Chain (Forged Drugs, etc)

5. Fraud Detection
   - 5.1 Introduction to Fraud Detection
   - 5.2 ICD-10 Codes
   - 5.3 Fraud Detection in Healthcare Management

6. Regulations and Ethics
   - 6.1 Legal & Regulatory Requirements
   - 6.2 Data Protection Foundations, GDPR
   - 6.3 Privacy in Machine Learning and AI
   - 6.4 Bias & Fairness in AI
   - 6.5 Explainable AI

Literature

Compulsory Reading

Further Reading

- Alleyn, T. et al (eds) (2020): Target Discovery and Validation: Methods and Strategies for Drug Discovery, Wiley.
- Antonopoulos, A. (2017): Mastering Bitcoin, 2nd ed. O'Reilley.
- Blass, B. (2015). Basic Principles of Drug Discovery and Development, Academic Press.
- Boccia, S. et al. (eds.) (2020): Personalised Health Care, Springer.
- Brown, N. (2020): Artificial Intelligence in Drug Discovery, Royal Society of Chemistry.
- Challen, R. et al. (2019). Artificial intelligence, bias and clinical safety. BMJ Quality & Safety, 28(3), 231-237.
- Costigliola, V. ed. (2012): Healthcare Overview: New Perspectives, Springer.
- Denton, B. (2013): Handbook of Healthcare Operations Management: Methods and Applications, Springer.
- Gupta, D. et al. (eds) (2020): Advanced Computational Intelligence Techniques for Virtual Reality in Healthcare, Springer.
- Hall, R. (ed) (2012): Handbook of Healthcare System Scheduling, Springer.
- IT Governance Privacy Team (2020): EU General Data Protection Regulation (GDPR) – An implementation and compliance guide, fourth edition, ITGP.
- Lantz, L., Cawrey, D. (2020): Mastering Blockchain, O'Reilley.
- Levine, A. et al. (eds) (2013) The Comprehensive Textbook of Healthcare Simulation, Springer.
- McCradden, M. D. et al. (2020). Patient safety and quality improvement: Ethical principles for a regulatory approach to bias in healthcare machine learning. Journal of the American Medical Informatics Association, 27(12), 2024-2027.
- Molnar, Ch. (2019), Interpretable Machine Learning, Lulu.
- O'Donnell, J. et al (eds.) (2021): Drug Discovery and Development, 3rd ed., CRC Press.
- Pinedo, M. (201): Scheduling: Theory, Algorithms, and Systems, 5th ed., Springer.
- Vissers, J. (2005): Health Operations Management.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Medical NLP

Course Code: DLMAIEMNMR01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01

Course Description

The course gives an introduction into natural language processing (NLP) with special focus to application in healthcare. After a general introduction, the course covers conventional statistical NLP models before turning to modern deep learning-based approaches based on word embeddings, recurrent neural networks or transformers. Subsequently, a range of application areas is discussed that can be used in healthcare. The course closes with a detailed analysis of application scenarios and case studies of natural language processing in healthcare.

Course Outcomes

On successful completion, students will be able to

- understand the concepts of natural language processing.
- analyze texts with statistical models.
- create deep learning-based NLP models.
- evaluate which NLP method is appropriate for a specific application scenario.

Contents

1. Introduction to NLP
   - 1.1 Human Language and Meaning of Words
   - 1.2 Challenges in NLP
   - 1.3 Bias
   - 1.4 Evaluation Metrics
2. Language Modeling and Word Representation
   - 2.1 N-Grams
   - 2.2 Bag of Words and Word Vectors
   - 2.3 Word Embedding Models
3. NLP with Deep Learning
   - 3.1 Recurrent Neural Network based Approaches
   - 3.2 Transformer based Approaches

4. NLP Tasks
   - 4.1 Named Entity Recognition
   - 4.2 Sentiment Analysis
   - 4.3 Text Summarization
   - 4.4 Machine Translation
   - 4.5 Speech Recognition & Synthesis
   - 4.6 Text Understanding & Information Extraction

5. Application Scenarios & Case Studies
   - 5.1 Medical Text Analysis
   - 5.2 Medical Chatbots
   - 5.3 Diagnostics and Therapy
   - 5.4 Drug Discovery

Literature

Compulsory Reading

Further Reading

- Clark, A., Fox, C., & Lappin, S. (Eds.). (2010). Handbook of computational linguistics and natural language processing. Malden, MA: Wiley-Blackwell.
- Devlin, J. et al (2018). Bert: Pre-training of deep bidirectional transformers for language understanding. arXiv preprint arXiv:1810.04805.
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- Kandpal, P. et al (2020): Contextual Chatbot for Healthcare Purposes (using Deep Learning), Fourth World Conference on Smart Trends in Systems, Security and Sustainability (WorldS4), 2020, pp. 625-634, doi: 10.1109/WorldS450073.2020.9210351
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- Sun, T. et al. (2019). Mitigating Gender Bias in Natural Language Processing: Literature Review, arXiv pre-print 1906.08976
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- Zand, A. et al (2020): An Exploration Into the Use of a Chatbot for Patients With Inflammatory Bowel Diseases: Retrospective Cohort Study. Journal of medical Internet research, 22(5), e15589. https:/ /doi.org/10.2196/15589

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

AI in Healthcare and Medical Robotics

Module Code: DLMAIEHMR

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Ulrich Kerzel (AI in Healthcare) / Prof. Dr. Ulrich Kerzel (Medical Robotics and Devices)

Contributing Courses to Module

- AI in Healthcare (DLMAIEHCMI01)
- Medical Robotics and Devices (DLMAIEMNMR02)

Module Exam Type

Module Exam	Split Exam
	AI in Healthcare • Study Format "Distance Learning": Exam, 90 Minutes Medical Robotics and Devices • Study Format "Distance Learning": Written Assessment: Case Study

Weight of Module
see curriculum

Module Contents

AI in Healthcare

- Healthcare Stakeholders
- Drug Discovery
- Personalized Care
- Blockchain in Healthcare
- Fraud Detection
- Regulations and Ethics

Medical Robotics and Devices

- Internet of Medical Things
- Wearable and Implantable Devices
- Fundamentals of Robotics
- Navigation and Registration
- Treatment Planning
- Design of Medical Robots

Learning Outcomes

AI in Healthcare

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

Medical Robotics and Devices

On successful completion, students will be able to

- understand the current developments, the main issues, and the challenges of robotics for the medical field.
- describe typical applications and requirements of medical robots.
- address the problems of navigation and registration in medical field.
- solve basic design issues related to medical robots.
- understand and describe the main wearable and implantable medical devices.
- understand the main characteristics and challenges related to the internet of medical things.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the fields of Data Science & Artificial Intelligence and Engineering.	All Master Programs in the IT & Technology field.

AI in Healthcare

Course Code: DLMAIEHCMI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

The course gives an overview over a wide range of topics in which artificial intelligence has the potential to transform the way healthcare operates. The course starts with an introduction to the key stakeholders in healthcare. Afterwards, discovery of new drugs and medicines are discussed where artificial intelligence is already starting to make a big impact. Next, the topics personalized care, blockchain in healthcare and fraud detection are discussed which are key drivers in the digitalization of healthcare in the future. Finally, the course covers the foundations of regulations and ethics in healthcare with a strong focus on data driven methods and artificial intelligence, including data protection, bias in AI and explainable AI methods.

Course Outcomes

On successful completion, students will be able to

- remember the key stakeholders in healthcare.
- understand how artificial intelligence can be used in a wide range of healthcare applications.
- evaluate the impact of data driven methods and artificial intelligence in healthcare applications.
- analyze the impact of regulatory or ethical requirements on the development of data driven methods and artificial intelligence in healthcare.

Contents

1. Healthcare Stakeholders
   - 1.1 Healthcare Management
   - 1.2 Insurance & Intermediaries
   - 1.3 Pre-Clinical & Clinical Care Providers
   - 1.4 GP & Specialist Care
   - 1.5 Industry (Pharma / Medical Products)
   - 1.6 Patents & Society
2. Drug Discovery
   - 2.1 Drug Discovery Approaches
   - 2.2 AI in Drug Discovery

3. Personalized Care
   - 3.1 Medication Monitoring
   - 3.2 Virtual Nursing Assistants

4. Blockchain in Healthcare
   - 4.1 Introduction to Blockchains & Medical Blockchains
   - 4.2 Blockchain in Organ Procurement
   - 4.3 Blockchain for Electronic Health Records (EHR)
   - 4.4 Blockchain for Pharma Supply Chain (Forged Drugs, etc)

5. Fraud Detection
   - 5.1 Introduction to Fraud Detection
   - 5.2 ICD-10 Codes
   - 5.3 Fraud Detection in Healthcare Management

6. Regulations and Ethics
   - 6.1 Legal & Regulatory Requirements
   - 6.2 Data Protection Foundations, GDPR
   - 6.3 Privacy in Machine Learning and AI
   - 6.4 Bias & Fairness in AI
   - 6.5 Explainable AI

Literature

Compulsory Reading

Further Reading

- Alleyn, T. et al (eds) (2020): Target Discovery and Validation: Methods and Strategies for Drug Discovery, Wiley.
- Antonopoulos, A. (2017): Mastering Bitcoin, 2nd ed. O'Reilley.
- Blass, B. (2015). Basic Principles of Drug Discovery and Development, Academic Press.
- Boccia, S. et al. (eds.) (2020): Personalised Health Care, Springer.
- Brown, N. (2020): Artificial Intelligence in Drug Discovery, Royal Society of Chemistry.
- Challen, R. et al. (2019). Artificial intelligence, bias and clinical safety. BMJ Quality & Safety, 28(3), 231-237.
- Costigliola, V. ed. (2012): Healthcare Overview: New Perspectives, Springer.
- Denton, B. (2013): Handbook of Healthcare Operations Management: Methods and Applications, Springer.
- Gupta, D. et al. (eds) (2020): Advanced Computational Intelligence Techniques for Virtual Reality in Healthcare, Springer.
- Hall, R. (ed) (2012): Handbook of Healthcare System Scheduling, Springer.
- IT Governance Privacy Team (2020): EU General Data Protection Regulation (GDPR) – An implementation and compliance guide, fourth edition, ITGP.
- Lantz, L., Cawrey, D. (2020): Mastering Blockchain, O'Reilley.
- Levine, A. et al. (eds) (2013) The Comprehensive Textbook of Healthcare Simulation, Springer.
- McCradden, M. D. et al. (2020). Patient safety and quality improvement: Ethical principles for a regulatory approach to bias in healthcare machine learning. Journal of the American Medical Informatics Association, 27(12), 2024-2027.
- Molnar, Ch. (2019), Interpretable Machine Learning, Lulu.
- O'Donnell, J. et al (eds.) (2021): Drug Discovery and Development, 3rd ed., CRC Press.
- Pinedo, M. (201): Scheduling: Theory, Algorithms, and Systems, 5th ed., Springer.
- Vissers, J. (2005): Health Operations Management.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Medical Robotics and Devices

Course Code: DLMAIEMNMR02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01

Course Description

The growing interconnection between medical devices and medical objects is leading to the so-called Internet of Medical Things, which can be seen as a specific use case of the more generic Internet of Things. However, medical objects do have some peculiarities, for instance due to specific, sometimes more stringent regulations and requirements. This course introduces two main kind of medical objects, namely medical robots and wearable and implantable devices. The first part focuses on wearable and implantable devices, for use in patient monitoring or activity tracking. The second part focuses medical robots, by presenting the fundamentals as well as specific topics in the medical field, such as navigation, registration and treatment planning. The course ends with an overview on the main issues to be considered when designing a medical robot.

Course Outcomes

On successful completion, students will be able to

- understand the current developments, the main issues, and the challenges of robotics for the medical field.
- describe typical applications and requirements of medical robots.
- address the problems of navigation and registration in medical field.
- solve basic design issues related to medical robots.
- understand and describe the main wearable and implantable medical devices.
- understand the main characteristics and challenges related to the internet of medical things.

Contents

1. Internet of Medical Things
    - 1.1 Medical Robots
    - 1.2 Data-Driven Medicine
    - 1.3 Image Management
    - 1.4 Cybersecurity
    - 1.5 Current Legislation and Trends

2. Weareable and Implantable Medical Devices
   - 2.1 Weareable Devices
   - 2.2 Weareable Sensors for Monitoring
   - 2.3 Implantable Devices

3. Fundamentals of Robotics: Kinematics
   - 3.1 Kinematics
   - 3.2 Position and Orientation of a Rigid Body
   - 3.3 Joint Kinematics
   - 3.4 Forward Kinematics
   - 3.5 Inverse Kinematics
   - 3.6 Differential Kinematics

4. Navigation and Registration
   - 4.1 Digitally Reconstructed Radiographs
   - 4.2 Points and Landmarks
   - 4.3 Contour-Based Registration
   - 4.4 Intensity-Based Registration
   - 4.5 Image Deformation
   - 4.6 Hand-Eye Calibration

5. Treatment Planning
   - 5.1 Orthopedic Surgery
   - 5.2 Radiosurgery
   - 5.3 Four-Dimensional Planning

6. Design of Medical Robots
   - 6.1 Kinematics and Dynamics
   - 6.2 Design Methods
   - 6.3 Actuators, Sensors, and Material
   - 6.4 Security and Safety

Literature
Compulsory Reading
Further Reading ▪ Cardona, M., Solanki, V. K., & Garcia Cena, C. E. (Eds.). (2021). Internet of Medical Things. Boca Raton: CRC Press. ▪ Schweikard, A., & Ernst, F. (2015). Medical Robotics. Springer International Publishing. https://doi.org/10.1007/978-3-319-22891-4 ▪ Troccaz, J. (Ed.). (2013). Medical Robotics. John Wiley and Sons. https://doi.org/10.1002/9781118562147

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

AI in E-Commerce, Marketing and Demand Forecast

Module Code: DLMAIEECMDF

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

N.N. Professur für Artificial Intelligence (Introduction to AI in E-Commerce and Marketing) / N.N. Professur für Artificial Intelligence (Demand Forecast and Inventory Control)

Contributing Courses to Module

- Introduction to AI in E-Commerce and Marketing (DLMAIEECMDF01)
- Demand Forecast and Inventory Control (DLMAIEECMDF02)

Module Exam Type

Module Exam	Split Exam
	Introduction to AI in E-Commerce and Marketing • Study Format "Distance Learning": Written Assessment: Case Study Demand Forecast and Inventory Control • Study Format "Distance Learning": Exam or Written Assessment: Case Study, 90 Minutes

Weight of Module
see curriculum

Module Contents

Introduction to AI in E-Commerce and Marketing

- Application Areas and Historical Review
- Virtual Assistants
- Visual Search
- Dynamic Pricing
- Regulatory Requirements & Ethics
- Case Studies

Demand Forecast and Inventory Control

- Newsvendor Model
- Traditional Methods of Demand Forecasting
- Data Driven methods of Demand Forecasting
- Inventory Models
- Further Effects

Learning Outcomes

Introduction to AI in E-Commerce and Marketing

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

Demand Forecast and Inventory Control

On successful completion, students will be able to

- understand the concepts of demand forecasting and inventory control.
- evaluate which method is appropriate in a specific application scenario.
- analyze which effects need to be considered in demand forecasting or inventory control models.
- create demand forecasting models using the methods discussed in the course.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Introduction to AI in E-Commerce and Marketing

Course Code: DLMAIEECMDF01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

This course gives a general introduction to the use of artificial intelligence in the application domain of E-Commerce and Marketing. First, the general application areas are introduced and set into a historical context. This is then developed deeper in dedicated learning units focused on virtual assistants and visual search. Determining the optimal price for a product or service is crucial to all aspects in E-Commerce and Marketing, a dedicated learning unit covers the theoretical foundations before turning to discussing methods how to adapt prices dynamically. The use of artificial intelligence requires extensive use of data. In particular in marketing and E-Commerce, personal data are often processed, a dedicated learning unit covers both the regulatory aspects of which data may be processed and under which circumstances, as well as ethical considerations of how to use data responsibly within the allowed remit. Finally, a number of case studies are discussed to illustrate the use of artificial intelligence in E-Commerce and Marketing.

Course Outcomes

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

Contents

1. Application Areas and Historical Review
    - 1.1 Retail
    - 1.2 Entertainment
    - 1.3 Advertising
    - 1.4 Internet of Things

2. Virtual Assistants
   - 2.1 NLP Fundamentals
   - 2.2 NLP with Deep Learning
   - 2.3 Chatbots
   - 2.4 Voice Search

3. Visual Search
   - 3.1 Computer Vision Fundamentals
   - 3.2 Computer Vision with Deep Learning
   - 3.3 Visual Product Search

4. Dynamic Pricing
   - 4.1 Pricing Theory
   - 4.2 Measuring Price Elasticity
   - 4.3 Bayesian Optimal Pricing
   - 4.4 Dynamic Pricing

5. Regulatory Requirements & Ethics
   - 5.1 Data Protection and Data Privacy
   - 5.2 Ethical Data Usage and Modeling

6. Case Studies
   - 6.1 Retail
   - 6.2 Entertainment
   - 6.3 Advertisement

Literature
Compulsory Reading
Further Reading ▪ Chaffey, D. (2019): Digital Business and E-Commerce Management, 7th ed. Pearson. ▪ Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall. ▪ Friedman, D. (1986): Price Theory: An Intermediate Text, South-Western Publishing Co. ▪ IT Governance Privacy Team (2020): EU General Data Protection Regulation (GDPR) – An implementation and compliance guide, fourth edition, ITGP. ▪ Landsburg, St. (2013): Price Theory and Applications, Cengage Learning; 9th edition. ▪ Laudon, K./Traver, C. G. (2020): E-Commerce. Business. Technology. Society. 16. Auflage, Pearson. ▪ Martin, J., Jurafsky, D. (2008): Speech and Language Processing, 2nd ed., Prentice Hall. ▪ Rogers, D. L. (2016): The digital transformation playbook: Rethink your business for the digital age. Columbia Business School Publishing, New York. ▪ Szeliski,R. (2010):Computer Vision - Algorithms and Applications, Springer, 2010.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Demand Forecast and Inventory Control

Course Code: DLMAIEECMDF02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01

Course Description

The course gives a general overview of traditional and modern methods used for demand forecasting and inventory control. Starting from the classic newsvendor model and its extensions, the course covers the fundamental aspects of dealing with uncertain demand, including censored data. The course then covers methods used for demand forecasting, starting with more traditional approaches such as exponential smoothing and ARIMA time-series analysis, as well as state-space models and structural time series-based approaches. Next, data-driven and machine learning based approaches are discussed, including methods that exploit the temporal order of, for example, sales data in the forecast and supervised methods that can be used without. To highlight the challenge in exploiting the auto-correlation, the effects of causal relationships in time-series forecasting, in particular temporal confounding are addressed. Further, methods that avoid demand forecasting altogether such as the “Big Data Newsvendor” and similar approaches are discussed. The course then turns towards inventory models, including, for example, models with review such as (s,S) based models. Finally, the course covers a range of topics that are particularly important for practical applications, such as including customer heterogeneity, or the retirement of old and inclusion of new products in the assortment, as well as discussing how to derive operational KPIs that can be used to monitor the replenishment process in practice.

Course Outcomes

On successful completion, students will be able to

- understand the concepts of demand forecasting and inventory control.
- evaluate which method is appropriate in a specific application scenario.
- analyze which effects need to be considered in demand forecasting or inventory control models.
- create demand forecasting models using the methods discussed in the course.

Contents

Literature

Compulsory Reading

Further Reading

- Ban GY, Rudin C (2019) The big data newsvendor: Practical insights from machine learning. Oper Res 67(1):90–108
- Bertsimas D, Kallus N (2020) From predictive to prescriptive analytics. Manag Sci 66(3):1025–1044
- Bica I, Alaa A, Van Der Schaar M (2020) Time series deconfounder: Estimating treatment effects over time in the presence of hidden confounders. In: International Conference on Machine Learning. PMLR, pp 884–895
- Brodersen KH, Gallusser F, Koehler J, Remy N, Scott SL (2015) Inferring causal impact using Bayesian structural time-series models. Ann Appl Stat 9:247–274
- De Gooijer JG, Hyndman RJ (2006) 25 years of time series forecasting. Int J Forecast 22(3):443–473
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- Huber J, Müller S, Fleischmann M, Stuckenschmidt H (2019) A data-driven newsvendor problem: From data to decision. Eur J Oper Res 278(3):904–915
- Hyndman R, Koehler AB, Ord JK, Snyder RD (2008) Forecasting with exponential smoothing: the state space approach. Springer Science & Business Media
- Khouj, M (1999) The single-period (news-vendor) problem: literature review and suggestions for future research. Omega 27(5):537–553
- Längkvist M, Karlsson L, Loutfi A (2014) A review of unsupervised feature learning and deep learning for time-series modeling. Pattern Recogn Lett 42:11–24
- Lim B, Arik SO, Loeff N, Pfister T (2019) Temporal fusion transformers for interpretable multi-horizon time series forecasting. arXiv preprint arXiv:1912.09363
- Malinsky D, Spirtes P (2018) Causal structure learning from multivariate time series in settings with unmeasured confounding. In: Proceedings of 2018 ACM SIGKDD Workshop on Causal Discovery, pp 23–47
- Nahmias, S. , Pierskalla, W. (1973) Optimal ordering policies for a product that perishes in two periods subject to stochastic demand. Naval Research Logistics Quarterly, 20(2):207{229, 1973.
- Porteus, E. (1983) Inventory Policies for Periodic Review Systems. Research Papers 650, Stanford University, Graduate School of Business, June 1983.
- Rasul K, Sheikh AS, Schuster I, Bergmann U, Vollgraf R (2020) Multi-variate probabilistic time series forecasting via conditioned normalizing flows. arXiv preprint arXiv:2002.06103
- Runge J (2018) Causal network reconstruction from time series: From theoretical assumptions to practical estimation. Chaos Int J Nonlinear Sci 28(7):075310
- Scarf, H. (1959) Bayes solutions of the statistical inventory problem. Ann. Math. Statist., 30(2):490{508, 06
- Vandeput, N. (2020) Inventory Optimization: Models and Simulations, De Gruyter
- Wick, F. et al. (2021) Demand Forecasting of Individual Probability Density Functions with Machine Learning. SN Oper. Res. Forum 2, 37. https://doi.org/10.1007/s43069-021-00079-8

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam or Written Assessment: Case Study, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

AI in E-Commerce, Marketing and Analytics

Module Code: DLMAIEECMA

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

N.N. Professur für Artificial Intelligence (Introduction to AI in E-Commerce and Marketing) / N.N. Professur für Artificial Intelligence (AI in Marketing and Analytics)

Contributing Courses to Module

- Introduction to AI in E-Commerce and Marketing (DLMAIEECMDF01)
- AI in Marketing and Analytics (DLMAIEAPRS01)

Module Exam Type

Module Exam	Split Exam
	Introduction to AI in E-Commerce and Marketing • Study Format "Distance Learning": Written Assessment: Case Study AI in Marketing and Analytics • Study Format "Distance Learning": Oral Assignment

Weight of Module
see curriculum

Module Contents

Introduction to AI in E-Commerce and Marketing

- Application Areas and Historical Review
- Virtual Assistants
- Visual Search
- Dynamic Pricing
- Regulatory Requirements & Ethics
- Case Studies

AI in Marketing and Analytics

- Foundation and Introduction
- Descriptive Methods
- Predictive Methods
- Prescriptive Methods
- Perspectives

Learning Outcomes

Introduction to AI in E-Commerce and Marketing

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

AI in Marketing and Analytics

On successful completion, students will be able to

- understand the concepts of data driven marketing.
- apply descriptive, predictive, and prescriptive marketing and analytics methods.
- evaluate applications of artificial intelligence in marketing and analytics.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology and Marketing field.

Introduction to AI in E-Commerce and Marketing

Course Code: DLMAIEECMDF01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

This course gives a general introduction to the use of artificial intelligence in the application domain of E-Commerce and Marketing. First, the general application areas are introduced and set into a historical context. This is then developed deeper in dedicated learning units focused on virtual assistants and visual search. Determining the optimal price for a product or service is crucial to all aspects in E-Commerce and Marketing, a dedicated learning unit covers the theoretical foundations before turning to discussing methods how to adapt prices dynamically. The use of artificial intelligence requires extensive use of data. In particular in marketing and E-Commerce, personal data are often processed, a dedicated learning unit covers both the regulatory aspects of which data may be processed and under which circumstances, as well as ethical considerations of how to use data responsibly within the allowed remit. Finally, a number of case studies are discussed to illustrate the use of artificial intelligence in E-Commerce and Marketing.

Course Outcomes

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

Contents

1. Application Areas and Historical Review
    - 1.1 Retail
    - 1.2 Entertainment
    - 1.3 Advertising
    - 1.4 Internet of Things

2. Virtual Assistants
   - 2.1 NLP Fundamentals
   - 2.2 NLP with Deep Learning
   - 2.3 Chatbots
   - 2.4 Voice Search

3. Visual Search
   - 3.1 Computer Vision Fundamentals
   - 3.2 Computer Vision with Deep Learning
   - 3.3 Visual Product Search

4. Dynamic Pricing
   - 4.1 Pricing Theory
   - 4.2 Measuring Price Elasticity
   - 4.3 Bayesian Optimal Pricing
   - 4.4 Dynamic Pricing

5. Regulatory Requirements & Ethics
   - 5.1 Data Protection and Data Privacy
   - 5.2 Ethical Data Usage and Modeling

6. Case Studies
   - 6.1 Retail
   - 6.2 Entertainment
   - 6.3 Advertisement

Literature
Compulsory Reading
Further Reading ▪ Chaffey, D. (2019): Digital Business and E-Commerce Management, 7th ed. Pearson. ▪ Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall. ▪ Friedman, D. (1986): Price Theory: An Intermediate Text, South-Western Publishing Co. ▪ IT Governance Privacy Team (2020): EU General Data Protection Regulation (GDPR) – An implementation and compliance guide, fourth edition, ITGP. ▪ Landsburg, St. (2013): Price Theory and Applications, Cengage Learning; 9th edition. ▪ Laudon, K./Traver, C. G. (2020): E-Commerce. Business. Technology. Society. 16. Auflage, Pearson. ▪ Martin, J., Jurafsky, D. (2008): Speech and Language Processing, 2nd ed., Prentice Hall. ▪ Rogers, D. L. (2016): The digital transformation playbook: Rethink your business for the digital age. Columbia Business School Publishing, New York. ▪ Szeliski,R. (2010):Computer Vision - Algorithms and Applications, Springer, 2010.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

AI in Marketing and Analytics

Course Code: DLMAIEAPRS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01

Course Description

This course lays the foundation to apply methods from artificial intelligence in the field of marketing and analytics. The course starts with a general introduction of the basic concepts and then covers the three main areas in detail: descriptive, predictive and prescriptive methods. In each area, the relevant concepts are introduced and discussed. In particular the potential of using artificial intelligence methods in each of these areas is highlighted. The course closes with a discussion of further perspective, illustrating how this field is likely to develop in the next few years.

Course Outcomes

On successful completion, students will be able to

- understand the concepts of data driven marketing.
- apply descriptive, predictive, and prescriptive marketing and analytics methods.
- evaluate applications of artificial intelligence in marketing and analytics.

Contents

1. Foundations and Introduction
   - 1.1 Basic Building Blocks
   - 1.2 Channels & Strategies
2. Descriptive Methods
   - 2.1 Business Intelligence
   - 2.2 Brand Metrics and Value
   - 2.3 Customer Segmentation, Journey and Acquisition Cost
   - 2.4 Market Basket & Assortment Analysis
   - 2.5 Search Analytics

3. Predictive Methods
   - 3.1 Customer Churn and Retention
   - 3.2 Customer Lifetime Value (CLV) Estimation
   - 3.3 Sales Forecasting and Budgeting
   - 3.4 Search-Optimization

4. Prescriptive Methods
   - 4.1 Pricing Strategies
   - 4.2 Upselling, Cross-selling
   - 4.3 Marketing Campaign Analytics and Optimization
   - 4.4 Targeting
   - 4.5 Marketing Experiments, Tests & Evaluation

5. Perspectives
   - 5.1 Closed Loop vs. Human-in-the-Loop, Active Learning
   - 5.2 Cross-Channel, Omnichannel and Subscriptions

Literature

Compulsory Reading

Further Reading

- Barker, M., Barker, D., Bormann, N. (2016): Social Media Marketing: A Strategic Approach 2nd Edition, Cengage Learning
- Butow, E. et al. (2020): Ultimate Guide to Social Media Marketing. Entrepreneur Press, Irvine
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- Grigsby, M.(2018): Marketing Analytics: A Practical Guide to Improving Consumer Insights Using Data Techniques, 2nd Edition, London
- Kerin, R. , Hartley, St. (2019): Marketing: The Core, 8th ed., McGraw-Hill
- McKinnon, B. (2019): What's Your Point?: The Brand Arrow - Define Your Point. Grow Your Brand, Grace and Down Publishing

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

DLMAIEAPRS01

AI in E-Commerce and Customer-centric Marketing

Module Code: DLMAIEECCCM

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

N.N. Professur für Artificial Intelligence (Introduction to AI in E-Commerce and Marketing) / N.N. Professur für Artificial Intelligence (Personalization and Recommender Systems)

Contributing Courses to Module

- Introduction to AI in E-Commerce and Marketing (DLMAIEECMDF01)
- Personalization and Recommender Systems (DLMAIEAPRS02)

Module Exam Type

Module Exam	Split Exam
	Introduction to AI in E-Commerce and Marketing • Study Format "Distance Learning": Written Assessment: Case Study Personalization and Recommender Systems • Study Format "Distance Learning": Oral Assignment

Weight of Module
see curriculum

Module Contents

Introduction to AI in E-Commerce and Marketing

- Application Areas and Historical Review
- Virtual Assistants
- Visual Search
- Dynamic Pricing
- Regulatory Requirements & Ethics
- Case Studies

Personalization and Recommender Systems

- Foundation and Introduction
- Collaborative Filtering
- Content-Based Filtering
- Hybrid Recommender Systems
- Large-Scale Recommender Systems
- Perspectives

Learning Outcomes

Introduction to AI in E-Commerce and Marketing

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

Personalization and Recommender Systems

On successful completion, students will be able to

- understand the concepts of personalization and recommender systems.
- evaluate the appropriate approach of recommender system methods for specific application scenarios.
- apply artificial intelligence methods in the field of recommender systems and personalization.
- evaluate the development of new technologies and its application in personalization and recommender systems.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the fields of Data Science & Artificial Intelligence and Marketing & Sales.	All Master Programs in the IT & Technology and Marketing & Communication fields.

Introduction to AI in E-Commerce and Marketing

Course Code: DLMAIEECMDF01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01

Course Description

This course gives a general introduction to the use of artificial intelligence in the application domain of E-Commerce and Marketing. First, the general application areas are introduced and set into a historical context. This is then developed deeper in dedicated learning units focused on virtual assistants and visual search. Determining the optimal price for a product or service is crucial to all aspects in E-Commerce and Marketing, a dedicated learning unit covers the theoretical foundations before turning to discussing methods how to adapt prices dynamically. The use of artificial intelligence requires extensive use of data. In particular in marketing and E-Commerce, personal data are often processed, a dedicated learning unit covers both the regulatory aspects of which data may be processed and under which circumstances, as well as ethical considerations of how to use data responsibly within the allowed remit. Finally, a number of case studies are discussed to illustrate the use of artificial intelligence in E-Commerce and Marketing.

Course Outcomes

On successful completion, students will be able to

- remember the application areas within E-Commerce and Marketing.
- understand the theory of setting prices.
- evaluate regulatory requirements and ethic considerations within the context of using artificial intelligence in E-Commerce and Marketing.
- understand the use of AI in virtual assistants and visual search.
- analyze relevant case studies.

Contents

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   - 6.1 Retail
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   - 6.3 Advertisement

Literature
Compulsory Reading
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Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Personalization and Recommender Systems

Course Code: DLMAIEAPRS02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01

Course Description

This course focuses on methods and applications of personalization techniques and recommender systems. After a general introduction to the topic and its foundation, content-based and collaborative filtering methods are discussed. Recommender systems play a vital role in modern personalization methods and both hybrid as well as large-scale approaches for recommender systems are discussed in detail in dedicated learning units. Finally, the course gives an outlook on developments of next generation methods as well as integration of further analytical methods such as causal analysis, multi-stakeholder and multi-objective recommender systems.

Course Outcomes

On successful completion, students will be able to

- understand the concepts of personalization and recommender systems.
- evaluate the appropriate approach of recommender system methods for specific application scenarios.
- apply artificial intelligence methods in the field of recommender systems and personalization.
- evaluate the development of new technologies and its application in personalization and recommender systems.

Contents

1. Foundation and Introduction
   - 1.1 History and Application Domains of Recommender Systems
   - 1.2 Basic Building Blocks:
   - 1.3 Levels of Personalization & Recommender Archetypes
   - 1.4 Business Goals & Evaluation Strategies
2. Collaborative Filtering
   - 2.1 Neighborhood-Based Approaches:
   - 2.2 Graph-Based Approaches
   - 2.3 Latent Factor Models
   - 2.4 Bayesian Personalized Ranking (BPR)

3. Content-based Filtering
   - 3.1 Content Types & Strategies across Domains
   - 3.2 Factorization Machines & Classification

4. Hybrid Recommender Systems
   - 4.1 User- vs. Item-based Recommendations
   - 4.2 Monolithic, Mixed Hybrid and Ensemble Recommenders

5. Large-Scale Recommender Systems
   - 5.1 Information Retrieval Dichotomy
   - 5.2 Approximate Nearest Neighbour Search
   - 5.3 Serving Recommendations in Production

6. Perspectives
   - 6.1 (Contextual) Multi-Armed Bandits
   - 6.2 Deep Learning and Reinforcement Learning Based Approaches
   - 6.3 Causality-Aware Approaches
   - 6.4 Multi-Stakeholder and Multi-Objective Recommender Systems

Literature

Compulsory Reading

Further Reading

- Aggarwal, C. (2016): Recommender Systems, Springer.
- Falk, K, (2019): Practical Recommender Systems, Manning Publications.
- Jannach, D., Zanker, M., Felfernig, A, Friedrich, G. (2010): Recommender Systems: An Introduction, Cambridge University Press.
- Moreira, G., Cunha, A. (2020): Deep Learning for News Recommender Systems, LAP LAMBERT Academic Publishing.
- Pearl, J., Glymour, M., & Jewell, N. P. (2016). Causal inference in statistics: A primer. Wiley.
- RecSys '20: Fourteenth ACM Conference on Recommender Systems, Association for Computing Machinery, New York, NY, United States, ISBN 78-1-4503-7583-2
- Sutton,R. S.,& Barto, A. G. (1998). Reinforcement learning: An introduction. MIT Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Industrial AI

Module Code: DLMAIEIAI

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEIAI01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Leonardo Riccardi (AI in Production) / Prof. Dr. Marian Benner-Wickner (Project: Industrial Internet of Things)

Contributing Courses to Module

- AI in Production (DLMAIEIAI01)
- Project: Industrial Internet of Things (DLMAIEIAI02)

Module Exam Type

Module Exam	Split Exam
	AI in Production • Study Format "Distance Learning": Oral Assignment Project: Industrial Internet of Things • Study Format "Distance Learning": Oral Project Report

Weight of Module

see curriculum

Module Contents

AI in Production

- Introduction to Smart Factory
- AI for Design
- AI for Quality
- AI for Supply Chain
- AI for autonomous planning and Scheduling

Project: Industrial Internet of Things

In this course the student will learn how to design a basic IIoT system which uses common protocols, data sources, sensors and architectural paradigms of the industrial field.

Learning Outcomes

AI in Production

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Project: Industrial Internet of Things

On successful completion, students will be able to

- understand industrial use-cases of internet of things.
- understand commonly used devices and protocols.
- work with diverse industrial data sources and sensors.
- describe data flows within production facilities.
- design a basic IoT architecture for industrial scenarios.
- understand cybersecurity issues and consider them for the design of an industrial IoT architecture.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Engineering.	All Master Programs in the IT & Technology field.

AI in Production

Course Code: DLMAIEIAI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01

Course Description

Production is undergoing a revolution thanks to the adoption of AI technologies, both for single processes and strategic decisions. This course gives an overview on the changing production paradigm, introducing the concept and the main characteristics of a smart factory. After that, the course illustrates some common uses cases of AI in production, such as Design, Quality, Supply Chain, and autonomous planning and scheduling, the latter being very important for the successful implementation of cyber-physical systems in the context of the industrial internet of things.

Course Outcomes

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Contents

1. Introduction: The Smart Factory
   - 1.1 Goals of a Smart Factory
   - 1.2 Internet of Things
   - 1.3 Cyber-Physical Systems
   - 1.4 Cyber-Physical Production Systems
   - 1.5 A New Paradigm for Automation

2. Basics of a Smart Factory
   - 2.1 Intelligent Products, Object Identification and Digital Object Memory
   - 2.2 Formal Languages and Ontologies
   - 2.3 Autonomous Cooperation
   - 2.4 Humans & Machines
   - 2.5 Order-Controller Production
   - 2.6 Smart Services

3. AI for Design
   - 3.1 Generative Design
   - 3.2 Methods
4. AI for Quality
   - 4.1 Fault Detection & Identification
   - 4.2 Predictive and Prescriptive Maintenance
   - 4.3 Defect Recognition
5. AI for Supply Chain
   - 5.1 Demand Forecasting
   - 5.2 Inventory Models
6. AI for Autonomous Planning and Scheduling
   - 6.1 Introduction
   - 6.2 Methods

Literature

Compulsory Reading

Further Reading

- Dafflon, B. Moalla, N., & Ouzrout, Y. (2021). The challenges, approaches, and used techniques of CPS for manufacturing in Industry 4.0: a literature review. The International Journal of Advanced Manufacturing Technology, 113(7), 2395–2412. https://doi.org/10.1007/s00170-020-06572-4
- Mahmood, Z. (Ed.). (2019). The Internet of Things in the Industrial Sector. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-24892-5
- Manesis, S., & Nikolakopoulos, G. (2020). Introduction to industrial automation. CRC Press, Taylor & Francis Group.
- Singh, K. K., Nayyar, A., Tanwar, S., & Abouhawwash, M. (Eds.). (2021). Emergence of Cyber Physical System and IoT in Smart Automation and Robotics. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-66222-6

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Project: Industrial Internet of Things

Course Code: DLMAIEIAI02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEIAI01

Course Description

By means of AI, data generated during a production process (or a complete product lifecycle) can be effectively analyzed and leveraged to achieve improvements in the sense of productivity, design, quality, customer satisfaction, strategic planning. This course gives a hands-on introduction to how the data is generated, i.e., which are the processes and devices, what is a typical industrial data flow, what is a typical hardware and software architecture of the industrial internet of things. Attention is given to common cybersecurity issues, which should play a fundamental role while designing an effective, secure architecture.

Course Outcomes

On successful completion, students will be able to

- understand industrial use-cases of internet of things.
- understand commonly used devices and protocols.
- work with diverse industrial data sources and sensors.
- describe data flows within production facilities.
- design a basic IoT architecture for industrial scenarios.
- understand cybersecurity issues and consider them for the design of an industrial IoT architecture.

Contents

- In this course the student will learn how to design a basic IIoT system which uses common protocols, data sources, sensors and architectural paradigms of the industrial field.

Literature
Compulsory Reading
Further Reading ▪ Dafflon, B., Moalla, N., & Ouzrout, Y. (2021). The challenges, approaches, and used techniques of CPS for manufacturing in Industry 4.0: a literature review. The International Journal of Advanced Manufacturing Technology, 113(7), 2395–2412. https://doi.org/10.1007/s00170-020-06572-4 ▪ Manesis, S., & Nikolakopoulos, G. (2020). Introduction to industrial automation. CRC Press, Taylor & Francis Group. ▪ Veneri, G., & Capasso, A. (2018). Hands-On Industrial Internet of Things. Packt. Retrieved from https://www.packtpub.com/product/hands-on-industrial-internet-of-things/9781789537222

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Oral Project Report

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Industrial Production Systems

Module Code: DLMAIEIPS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01 ▪ none	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator
Prof. Dr. Leonardo Riccardi (AI in Production) / Prof. Dr. Leonardo Riccardi (Industrial Automation)

Contributing Courses to Module
▪ AI in Production (DLMAIEIAI01) ▪ Industrial Automation (DLMDSINDA01)

Module Exam Type	
Module Exam	**Split Exam** AI in Production • Study Format "Distance Learning": Oral Assignment Industrial Automation • Study Format "Distance Learning": Exam, 90 Minutes
Weight of Module see curriculum	

Module Contents

AI in Production

- Introduction to Smart Factory
- AI for Design
- AI for Quality
- AI for Supply Chain
- AI for autonomous planning and Scheduling

Industrial Automation

- Mathematical Frameworks for the Formal Description of Discrete Event Systems
- Analysis and Evaluation Methods
- Simulation of Discrete Event Systems
- Supervisory Control
- Advanced Issues (Fault Diagnosis, Adaptive Supervision, Optimization)

Learning Outcomes

AI in Production

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Industrial Automation

On successful completion, students will be able to

- identify the main issues related to industrial automation and Industry 4.0 automation in particular.
- describe a discrete event system in a formal way by means of different mathematical models.
- analyze the performance of a system using formalisms and numerical simulation approaches.
- choose the best formalism for a given design scenario and formulate requirements.
- design and implement a supervisory controller to fulfill requirements.
- understand advanced topics related to Industry 4.0 industrial automation.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Engineering.	All Master Programs in the IT & Technology field.

AI in Production

Course Code: DLMAIEIAI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01

Course Description

Production is undergoing a revolution thanks to the adoption of AI technologies, both for single processes and strategic decisions. This course gives an overview on the changing production paradigm, introducing the concept and the main characteristics of a smart factory. After that, the course illustrates some common uses cases of AI in production, such as Design, Quality, Supply Chain, and autonomous planning and scheduling, the latter being very important for the successful implementation of cyber-physical systems in the context of the industrial internet of things.

Course Outcomes

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Contents

1. Introduction: The Smart Factory
   - 1.1 Goals of a Smart Factory
   - 1.2 Internet of Things
   - 1.3 Cyber-Physical Systems
   - 1.4 Cyber-Physical Production Systems
   - 1.5 A New Paradigm for Automation

2. Basics of a Smart Factory
   - 2.1 Intelligent Products, Object Identification and Digital Object Memory
   - 2.2 Formal Languages and Ontologies
   - 2.3 Autonomous Cooperation
   - 2.4 Humans & Machines
   - 2.5 Order-Controller Production
   - 2.6 Smart Services

3. AI for Design
   - 3.1 Generative Design
   - 3.2 Methods
4. AI for Quality
   - 4.1 Fault Detection & Identification
   - 4.2 Predictive and Prescriptive Maintenance
   - 4.3 Defect Recognition
5. AI for Supply Chain
   - 5.1 Demand Forecasting
   - 5.2 Inventory Models
6. AI for Autonomous Planning and Scheduling
   - 6.1 Introduction
   - 6.2 Methods

Literature

Compulsory Reading

Further Reading

- Dafflon, B. Moalla, N., & Ouzrout, Y. (2021). The challenges, approaches, and used techniques of CPS for manufacturing in Industry 4.0: a literature review. The International Journal of Advanced Manufacturing Technology, 113(7), 2395–2412. https://doi.org/10.1007/s00170-020-06572-4
- Mahmood, Z. (Ed.). (2019). The Internet of Things in the Industrial Sector. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-24892-5
- Manesis, S., & Nikolakopoulos, G. (2020). Introduction to industrial automation. CRC Press, Taylor & Francis Group.
- Singh, K. K., Nayyar, A., Tanwar, S., & Abouhawwash, M. (Eds.). (2021). Emergence of Cyber Physical System and IoT in Smart Automation and Robotics. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-66222-6

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Industrial Automation

Course Code: DLMDSINDA01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

Production systems can be described as discrete event systems where the evolution is characterized by the occurrence of events. In the era of Industry 4.0 and highly-flexible manufacturing, there is the need to provide adequate means for the modeling, analysis, design, and control of flexible production environments.This course introduces several modeling approaches for the mathematical description of discrete event systems, such as Automata, Petri Nets, and Markov processes. Each approach is presented in both theory and practice with examples taken from the industry. The approaches are grouped into logic—where only the logic sequence of events determines the evolution—and timed, where the time schedule of the events also plays an important role. Although simple discrete event systems can be analyzed mathematically, complex systems need the support of computer simulation. The main issues concerning the simulation of discrete event systems are addressed.The final part of this course introduces the concept of supervisory control, which aims at changing the properties of a given system to improve specified behaviors and fulfill defined design specifications. Supervisory control is addressed both from the theoretical practical sides, describing how it can be implemented in a modern industrial environment.The course wraps up with discussion of interesting applications for modeling and design approaches, e.g., in the modeling and analysis of an industrial production unit. Additional conversation on topics like fault-diagnosis, decentralized and distributed supervision, optimization, and adaptive supervision provide a contingent connection between classical industrial automation and the recent, (big) data-driven, flexible, Industry 4.0 advanced industrial automation.

Course Outcomes

On successful completion, students will be able to

- identify the main issues related to industrial automation and Industry 4.0 automation in particular.
- describe a discrete event system in a formal way by means of different mathematical models.
- analyze the performance of a system using formalisms and numerical simulation approaches.
- choose the best formalism for a given design scenario and formulate requirements.
- design and implement a supervisory controller to fulfill requirements.
- understand advanced topics related to Industry 4.0 industrial automation.

Contents

7. Applications
   - 7.1 Production system supervision
   - 7.2 Monitoring and diagnosis of faults
   - 7.3 Distributed and de-centralized supervision
   - 7.4 Model-based optimization of production systems
   - 7.5 Adaptive supervisory control

Literature

Compulsory Reading

Further Reading

- Cassandras, C. G., & Lafortune, S. (2009). Introduction to discrete event systems. Springer.
- Hooley, G., Nicoulaud, B., Rudd, J. M., & Piercy, N. (2019). Marketing strategy and competitive positioning. Pearson.
- Kaplan, R., Norton, D., & Rugelsjoen, B. (2010). Managing alliances with the balanced scorecard. Harvard Business Review, 88(1/2), 114—120.
- Linz, P. (2006). An introduction to formal languages and automata. Jones & Bartlett Learning.
- Reisig, W. (2013). Understanding Petri nets: Modeling techniques, analysis methods, case studies. Springer.
- Stewart, J. B. (2013, October 14). The collapse: How a top legal firm destroyed itself. The New Yorker.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

DLMDSINDA01

Computer Vision for Production Systems

Module Code: DLMAIECVPS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01 ▪ none	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Leonardo Riccardi (AI in Production) / Prof. Dr. Thomas Zöller (Computer Vision for Autonomous Systems)

Contributing Courses to Module

- AI in Production (DLMAIEIAI01)
- Computer Vision for Autonomous Systems (DLMAIEFSCVAS02)

Module Exam Type

Module Exam	Split Exam
	AI in Production • Study Format "Distance Learning": Oral Assignment Computer Vision for Autonomous Systems • Study Format "Distance Learning": Written Assessment: Written Assignment

Weight of Module

see curriculum

Module Contents

AI in Production

- Introduction to Smart Factory
- AI for Design
- AI for Quality
- AI for Supply Chain
- AI for autonomous planning and Scheduling

Computer Vision for Autonomous Systems

- Image Formation and Acquisition
- Sensors for Image Acquisition
- Feature Extraction
- Object Detection and Tracking
- Segmentation

Learning Outcomes

AI in Production

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Computer Vision for Autonomous Systems

On successful completion, students will be able to

- understand color and light.
- understand image formation.
- name commonly used sensors for image acquisition.
- perform basic image processing operations.
- detect features in an image.
- track objects in images and videos.
- apply commonly used algorithms for segmentation.

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field of Engineering.	All Master Programs in the IT & Technology field.

AI in Production

Course Code: DLMAIEIAI01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01

Course Description

Production is undergoing a revolution thanks to the adoption of AI technologies, both for single processes and strategic decisions. This course gives an overview on the changing production paradigm, introducing the concept and the main characteristics of a smart factory. After that, the course illustrates some common uses cases of AI in production, such as Design, Quality, Supply Chain, and autonomous planning and scheduling, the latter being very important for the successful implementation of cyber-physical systems in the context of the industrial internet of things.

Course Outcomes

On successful completion, students will be able to

- understand the evolution of automation in production.
- understand the main characteristics and goals of a Smart Factory.
- name some areas in which AI can be successfully adopted in production systems.
- describe some use cases of AI in production.

Contents

1. Introduction: The Smart Factory
   - 1.1 Goals of a Smart Factory
   - 1.2 Internet of Things
   - 1.3 Cyber-Physical Systems
   - 1.4 Cyber-Physical Production Systems
   - 1.5 A New Paradigm for Automation

2. Basics of a Smart Factory
   - 2.1 Intelligent Products, Object Identification and Digital Object Memory
   - 2.2 Formal Languages and Ontologies
   - 2.3 Autonomous Cooperation
   - 2.4 Humans & Machines
   - 2.5 Order-Controller Production
   - 2.6 Smart Services

3. AI for Design
   - 3.1 Generative Design
   - 3.2 Methods
4. AI for Quality
   - 4.1 Fault Detection & Identification
   - 4.2 Predictive and Prescriptive Maintenance
   - 4.3 Defect Recognition
5. AI for Supply Chain
   - 5.1 Demand Forecasting
   - 5.2 Inventory Models
6. AI for Autonomous Planning and Scheduling
   - 6.1 Introduction
   - 6.2 Methods

Literature

Compulsory Reading

Further Reading

- Dafflon, B. Moalla, N., & Ouzrout, Y. (2021). The challenges, approaches, and used techniques of CPS for manufacturing in Industry 4.0: a literature review. The International Journal of Advanced Manufacturing Technology, 113(7), 2395–2412. https://doi.org/10.1007/s00170-020-06572-4
- Mahmood, Z. (Ed.). (2019). The Internet of Things in the Industrial Sector. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-24892-5
- Manesis, S., & Nikolakopoulos, G. (2020). Introduction to industrial automation. CRC Press, Taylor & Francis Group.
- Singh, K. K., Nayyar, A., Tanwar, S., & Abouhawwash, M. (Eds.). (2021). Emergence of Cyber Physical System and IoT in Smart Automation and Robotics. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-66222-6

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Computer Vision for Autonomous Systems

Course Code: DLMAIEFSCVAS02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	none

Course Description

One of the main capabilities of an autonomous system, for instance a robot, is the ability to view and recognize objects. Object detection, recognition and tracking are advanced task of a modern computer vision system. This course introduces the fundamentals of computer vision, which rely on the beautiful mathematics of image formation as well as the technology of image acquisition. The images are further processed to extract information. Feature detection, object detection, object tracking and image segmentation are described. A chapter on sensors gives an overview of sensors used for computer vision in contemporary robotics and industry.

Course Outcomes

On successful completion, students will be able to

- understand color and light.
- understand image formation.
- name commonly used sensors for image acquisition.
- perform basic image processing operations.
- detect features in an image.
- track objects in images and videos.
- apply commonly used algorithms for segmentation.

Contents

1. Image Formation & Acquisition
   - 1.1 Light
   - 1.2 Color
   - 1.3 Perspective Camera
   - 1.4 Camera Calibration
   - 1.5 Single and Multiple View Geometry

2. Sensors for Computer Vision
   - 2.1 Camera & Night Vision
   - 2.2 Lidar
   - 2.3 Radar
   - 2.4 Ultrasound
   - 2.5 Trends

3. Image Processing
   - 3.1 Operators
   - 3.2 Filtering and Transforms
   - 3.3 Geometric Transformations

4. Feature Detection
   - 4.1 Points
   - 4.2 Edges
   - 4.3 Lines
   - 4.4 Common Methods

5. Object Detection & Tracking
   - 5.1 Object Representation
   - 5.2 Techniques for Object Detection
   - 5.3 Network Architectures

6. Segmentation
   - 6.1 Stuff and Things
   - 6.2 Semantic Segmentation
   - 6.3 Instance Segmentation
   - 6.4 Segmentation in Videos and Feeds
   - 6.5 MOTS: Multi-Object Tracking & Segmentation

Literature

Compulsory Reading

Further Reading

- Ansari, S. (2020). Building Computer Vision Applications Using Artificial Neural Networks. Apress. https://doi.org/10.1007/978-1-4842-5887-3
- Ayyadevara, V., & Reddy, Y. (2020). Modern Computer Vision with PyTorch. Packt.
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- Szelinski, R. (2020). Computer Vision: Algorithms and Applications. (2nd ed.). Springer Nature.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

NLP and its Application in Education

Module Code: DLMAIENLPAE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIWNLPVA01 ▪ DLMDSML01, DLMDSDL01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Tim Schlippe (Natural Language Processing) / Prof. Dr. Tim Schlippe (NLP in Education)

Contributing Courses to Module

- Natural Language Processing (DLMAIWNLPVA01)
- NLP in Education (DLMAIWNLPITE01)

Module Exam Type

Module Exam	Split Exam
	Natural Language Processing • Study Format "Distance Learning": Oral Assignment NLP in Education • Study Format "Distance Learning": Written Assessment: Research Essay

Weight of Module

see curriculum

Module Contents

Natural Language Processing

- Introduction to NLP
- Important Basic and Advanced Methods in NLP
- Relevant Applications in NLP
- Challenges in NLP and their Solutions

NLP in Education

This course strives to elucidate current research trends in „AI in Education“ with a focus on NLP.

Learning Outcomes

Natural Language Processing

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

NLP in Education

On successful completion, students will be able to

- discuss current trends and topics in the research field „AI in Education“ with a focus on NLP.
- learn to understand scientific publications in this field.
- understand algorithms and methods from the field of NLP to address an enhanced education.
- understand use-case scenarios in which NLP techniques are applied.
- learn to analyze, summarize, compare and describe the methods in a research essay.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Natural Language Processing

Course Code: DLMAIWNLPVA01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01

Course Description

In this course, traditional, state-of-the-art basic and advanced approaches to Natural Language Processing (NLP) will be taught. To achieve this goal, techniques, challenges, and solutions are presented with a comprehensive overview of related topics. Additionally, it will be shown how NLP can be used successfully in different use-case scenarios–both theoretically and with practical examples.

Course Outcomes

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

Contents

1. Introduction to NLP
   - 1.1 What is NLP?
   - 1.2 Syntax, Semantics and Prosodics
   - 1.3 Phonetics and Speech
   - 1.4 Evaluation of NLP Systems
2. Text Processing
   - 2.1 Word Vectors and Word Embeddings
   - 2.2 Regular Expressions
   - 2.3 Statistical Approaches
   - 2.4 Recurrent Neural Network based Approaches
   - 2.5 Transformer based Approaches
3. Speech Processing
   - 3.1 Statistical Speech Recognition and Synthesis
   - 3.2 Speech Recognition and Synthesis with Deep Learning

4. Application Scenarios
   - 4.1 Speech Recognition, Speech Synthesis and Machine Translation
   - 4.2 Information Extraction and Text Understanding
   - 4.3 Chatbots and Voice Assistants
   - 4.4 NLP in Education
   - 4.5 NLP with Python

5. Challenges in NLP
   - 5.1 Data for NLP
   - 5.2 Domain and Language Adaptation
   - 5.3 Explainability
   - 5.4 Bias

Literature

Compulsory Reading

Further Reading

- Bird S., Klein, E., & Loper, E. (2009): Natural language processing with Python. O'Reilly.
- Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3
- Kamath, U., Liu, J., & Whitaker, J. (2019): Deep Learning for NLP and Speech Recognition: Practical NLP, Speech, and Deep Learning using Python-based Open Source Tools. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

NLP in Education

Course Code: DLMAIWNLPITE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01

Course Description

Access to education is one of people's most important assets and ensuring inclusive and equitable quality education is goal 4 of United Nation's Sustainable Development Goals. Distance learning in particular can create education in areas where there are no educational institutions or in times of a pandemic. There are more and more offers for distance learning worldwide and challenges like the physical absence of the teacher and the classmates or the lack of motivation of the students are countered with technical solutions like videoconferencing systems and gamification of learning. The research area "AI in Education" addresses the application and evaluation of Artificial Intelligence (AI) methods in the context of education and training. One of the main focuses of this research is to analyze and improve teaching and learning processes. This course strives to elucidate current research trends in „AI in Education" with a focus on NLP. The students learn to independently analyze selected topics and case studies and link them with well-known concepts, as well as critically question and discuss them.

Course Outcomes

On successful completion, students will be able to

- discuss current trends and topics in the research field „AI in Education" with a focus on NLP.
- learn to understand scientific publications in this field.
- understand algorithms and methods from the field of NLP to address an enhanced education.
- understand use-case scenarios in which NLP techniques are applied.
- learn to analyze, summarize, compare and describe the methods in a research essay.

Contents

- The seminar covers current topics in the research field „AI in Education" with a focus on NLP. Each participant must write a research essay on a topic assigned to him/her.

Literature
Compulsory Reading
Further Reading ▪ Chen, L., Chen, P., & Lin, Z. (2020): Artificial Intelligence in Education: A Review. IEEE Access 8 (2020), 75264–75278. ▪ Heffernan, N. (2014): The ASSISTments Ecosystem: Building a Platform that Brings Scientists and Teachers Together for Minimally Invasive Research on Human Learning and Teaching. International Journal of Artificial Intelligence in Education 24 (12 2014). ▪ Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3 ▪ Libbrecht, P., Declerck, T., Schlippe, T., Mandl, T., & Schiffner, D. (2020): NLP for Student and Teacher: Concept for an AI based Information Literacy Tutoring System. In The 29th ACM International Conference on Information and Knowledge Management (CIKM2020). Galway, Ireland. ▪ Schlippe, T. & Sawatzki, J.(2021): AI-based Multilingual Interactive Exam Preparation. In The Learning Ideas Conference 2021 (14th annual conference). ALICE - Special Conference Track on Adaptive Learning via Interactive, Collaborative and Emotional Approaches. New York, USA. ▪ Schlippe, T. & Sawatzki, J. (2021): Cross-Lingual Automatic Short Answer Grading. In Proceedings of The 2nd International Conference on Artificial Intelligence in Education Technology (AIET 2021). Wuhan, China.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Natural Language Processing and Voice Assistants

Module Code: DLMAIWNLPVA

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01 ▪ DLMDSML01, DLMDSDL01, DLMAIWNLPVA01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Tim Schlippe (Natural Language Processing) / Prof. Dr. Tim Schlippe (Voice Assistants)

Contributing Courses to Module

- Natural Language Processing (DLMAIWNLPVA01)
- Voice Assistants (DLMAIWNLPVA02)

Module Exam Type

Module Exam	Split Exam
	Natural Language Processing • Study Format "Distance Learning": Oral Assignment Voice Assistants • Study Format "Distance Learning": Portfolio

Weight of Module

see curriculum

Module Contents

Natural Language Processing

- Introduction to NLP
- Important Basic and Advanced Methods in NLP
- Relevant Applications in NLP
- Challenges in NLP and their Solutions

Voice Assistants

In this course, the implementation of voice assistants with state-of-the-art methods and frameworks will be taught.

Learning Outcomes

Natural Language Processing

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

Voice Assistants

On successful completion, students will be able to

- implement voice assistant technology.
- understand use-case scenarios for voice assistants.
- analyze benefits and shortcomings of methods and frameworks for the implementation.
- combine the NLP components required for the implementation.
- explain the design choices made in the selection of the employed model and its implementation.
- apply common algorithms and methods to address NLP problems.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Natural Language Processing

Course Code: DLMAIWNLPVA01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01

Course Description

In this course, traditional, state-of-the-art basic and advanced approaches to Natural Language Processing (NLP) will be taught. To achieve this goal, techniques, challenges, and solutions are presented with a comprehensive overview of related topics. Additionally, it will be shown how NLP can be used successfully in different use-case scenarios–both theoretically and with practical examples.

Course Outcomes

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

Contents

1. Introduction to NLP
   - 1.1 What is NLP?
   - 1.2 Syntax, Semantics and Prosodics
   - 1.3 Phonetics and Speech
   - 1.4 Evaluation of NLP Systems
2. Text Processing
   - 2.1 Word Vectors and Word Embeddings
   - 2.2 Regular Expressions
   - 2.3 Statistical Approaches
   - 2.4 Recurrent Neural Network based Approaches
   - 2.5 Transformer based Approaches
3. Speech Processing
   - 3.1 Statistical Speech Recognition and Synthesis
   - 3.2 Speech Recognition and Synthesis with Deep Learning

4. Application Scenarios
   - 4.1 Speech Recognition, Speech Synthesis and Machine Translation
   - 4.2 Information Extraction and Text Understanding
   - 4.3 Chatbots and Voice Assistants
   - 4.4 NLP in Education
   - 4.5 NLP with Python

5. Challenges in NLP
   - 5.1 Data for NLP
   - 5.2 Domain and Language Adaptation
   - 5.3 Explainability
   - 5.4 Bias

Literature

Compulsory Reading

Further Reading

- Bird S., Klein, E., & Loper, E. (2009): Natural language processing with Python. O'Reilly.
- Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3
- Kamath, U., Liu, J., & Whitaker, J. (2019): Deep Learning for NLP and Speech Recognition: Practical NLP, Speech, and Deep Learning using Python-based Open Source Tools. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Voice Assistants

Course Code: DLMAIWNLPVA02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01

Course Description

In this course, the implementation of voice assistants with state-of-the-art methods and frameworks will be taught. To achieve this goal in a structured manner, the student will step-wise submit deliverables in a conception phase, a development/reflection phase, and in a finalization phase. In each phase the student will get feedback by the tutor to iteratively enhance and extent the implementation.

Course Outcomes

On successful completion, students will be able to

- implement voice assistant technology.
- understand use-case scenarios for voice assistants.
- analyze benefits and shortcomings of methods and frameworks for the implementation.
- combine the NLP components required for the implementation.
- explain the design choices made in the selection of the employed model and its implementation.
- apply common algorithms and methods to address NLP problems.

Contents

- The practical implementation and development of a voice assistant with digital documentations is combined as part of a portfolio which is designed and carried out individually but supervised by the responsible tutor. The implementation consists of three phases–the “conception phase”, the “development/reflection phase” and the “finalization phase”–which are intended to illustrate the individual work or development steps and the adopted approach. In the conception phase, the concept or core idea should be introduced as well as the initial motivation. Implementation of the basic ideas takes place in the implementation/reflection phase. In the finalization phase, the final product and/or a final version of the written assessment are developed and delivered.

Literature
Compulsory Reading
Further Reading ▪ Bird S., Klein, E., & Loper, E. (2009): Natural language processing with Python. O'Reilly. ▪ Bocklisch, T., Faulker, J., Pawlowski, N., Nichol, A. (2017): Rasa: Open Source Language Understanding and Dialogue Management. NIPS Workshop on Conversational AI. ▪ Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3 ▪ Kamath, U., Liu, J., & Whitaker, J. (2019): Deep Learning for NLP and Speech Recognition: Practical NLP, Speech, and Deep Learning using Python-based Open Source Tools. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☑ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

NLP and its Application for Accessibility

Module Code: DLMAIENLPAA

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIWNLPVA01 ▪ DLMDSML01, DLMDSDL01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Tim Schlippe (Natural Language Processing) / Prof. Dr. Tim Schlippe (NLP for Accessibility)

Contributing Courses to Module

- Natural Language Processing (DLMAIWNLPVA01)
- NLP for Accessibility (DLMAIWNLPITE02)

Module Exam Type

Module Exam	Split Exam
	Natural Language Processing • Study Format "Distance Learning": Oral Assignment NLP for Accessibility • Study Format "Distance Learning": Written Assessment: Research Essay

Weight of Module

see curriculum

Module Contents

Natural Language Processing

- Introduction to NLP
- Important Basic and Advanced Methods in NLP
- Relevant Applications in NLP
- Challenges in NLP and their Solutions

NLP for Accessibility

This course strives to elucidate current research trends in „NLP“ with a focus on accessibility, integration and inclusion.

Learning Outcomes

Natural Language Processing

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

NLP for Accessibility

On successful completion, students will be able to

- discuss current trends and topics in the research field „NLP“ with a focus on accessibility, inclusion and integration.
- learn to understand scientific publications in this field.
- understand algorithms and methods from the field of NLP to address accessibility, inclusion and integration.
- understand use-case scenarios in which NLP techniques are applied.
- learn to analyze, summarize, compare and describe the methods in a research essay.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Natural Language Processing

Course Code: DLMAIWNLPVA01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01

Course Description

In this course, traditional, state-of-the-art basic and advanced approaches to Natural Language Processing (NLP) will be taught. To achieve this goal, techniques, challenges, and solutions are presented with a comprehensive overview of related topics. Additionally, it will be shown how NLP can be used successfully in different use-case scenarios–both theoretically and with practical examples.

Course Outcomes

On successful completion, students will be able to

- get a good overview of the topic NLP.
- name important challenges in NLP.
- apply common algorithms and methods to address NLP problems.
- understand common use-case scenarios in which NLP techniques are applied.
- analyze benefits and shortcomings of various NLP algorithms.

Contents

1. Introduction to NLP
   - 1.1 What is NLP?
   - 1.2 Syntax, Semantics and Prosodics
   - 1.3 Phonetics and Speech
   - 1.4 Evaluation of NLP Systems
2. Text Processing
   - 2.1 Word Vectors and Word Embeddings
   - 2.2 Regular Expressions
   - 2.3 Statistical Approaches
   - 2.4 Recurrent Neural Network based Approaches
   - 2.5 Transformer based Approaches
3. Speech Processing
   - 3.1 Statistical Speech Recognition and Synthesis
   - 3.2 Speech Recognition and Synthesis with Deep Learning

4. Application Scenarios
   - 4.1 Speech Recognition, Speech Synthesis and Machine Translation
   - 4.2 Information Extraction and Text Understanding
   - 4.3 Chatbots and Voice Assistants
   - 4.4 NLP in Education
   - 4.5 NLP with Python

5. Challenges in NLP
   - 5.1 Data for NLP
   - 5.2 Domain and Language Adaptation
   - 5.3 Explainability
   - 5.4 Bias

Literature

Compulsory Reading

Further Reading

- Bird S., Klein, E., & Loper, E. (2009): Natural language processing with Python. O'Reilly.
- Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3
- Kamath, U., Liu, J., & Whitaker, J. (2019): Deep Learning for NLP and Speech Recognition: Practical NLP, Speech, and Deep Learning using Python-based Open Source Tools. Springer.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☑ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

NLP for Accessibility

Course Code: DLMAIWNLPITE02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01

Course Description

In recent years there has been an increasing interest in accessibility, inclusion and integration issues. This interest is mainly due to the greater importance of the Web and the need to provide equal opportunity to everyone including people with diverse diabilities or older people and to overcome language and cultural barriers. The role of assistive technologies based on NLP has gained importance. This course strives to elucidate current research trends in „NLP“ with a focus on accessibility, integration and inclusion. The students learn to independently analyze selected topics and case studies and link them with well-known concepts, as well as critically question and discuss them.

Course Outcomes

On successful completion, students will be able to

- discuss current trends and topics in the research field „NLP“ with a focus on accessibility, inclusion and integration.
- learn to understand scientific publications in this field.
- understand algorithms and methods from the field of NLP to address accessibility, inclusion and integration.
- understand use-case scenarios in which NLP techniques are applied.
- learn to analyze, summarize, compare and describe the methods in a research essay.

Contents

- The course covers current topics in the research field „NLP“ with a focus on accessibility, inclusion and integration.

Literature
Compulsory Reading
Further Reading ▪ Al-Thanyyan, S. S. & Azmi, A. (2021): Automated Text Simplification: A Survey. ACM Computing Surveys, Vol. 54, Issue 2, pp. 1–36. ▪ Jurafsky, D., & Martin, J. H. (2020): Speech and language processing (3rd ed.). PrenticeHall. https://web.stanford.edu/~jurafsky/slp3 ▪ Klaper, D., Ebling, S., & Volk, M. (2013): Building a German/Simple German Parallel Corpus for Automatic Text Simplification. The Second Workshop on Predicting and Improving Text Readibility for Target Reader Populations. ▪ Schlippe, T., Alessai, S., El-Taweel, G., Wölfel, M., & Zaghouani, W. (2020): Visualizing Voice Characteristics with Type Design in Closed Captions for Arabic. Cyberworlds. Caen, France.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☐ Reader
☐ Exam Template	☑ Slides

Computer Vision Essentials

Module Code: DLMAIWCVE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	▪ DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIWCVE01 ▪ DLMDSML01, DLMDSDL01, DLMAIRIL01	MA	10	300 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Thomas Zöller (Low to Mid-Level Vision) / Prof. Dr. Thomas Zöller (Mid to High-Level Vision)

Contributing Courses to Module

- Low to Mid-Level Vision (DLMAIWCVE01)
- Mid to High-Level Vision (DLMAIWCVE02)

Module Exam Type

Module Exam	Split Exam
	Low to Mid-Level Vision • Study Format "Distance Learning": Exam, 90 Minutes Mid to High-Level Vision • Study Format "Distance Learning": Written Assessment: Written Assignment

Weight of Module

see curriculum

Module Contents

Low to Mid-Level Vision

- Image Representation & Morphology
- Filtering
- Mid-Level Image Features
- Segmentation
- Motion

Mid to High-Level Vision

- Tracking
- Classification
- Recognition
- Image Synthesis
- Current Challenges

Learning Outcomes

Low to Mid-Level Vision

On successful completion, students will be able to

- understand fundamental concepts in image acquisition
- know how to apply morphological operations
- describe important types of midlevel image features
- differentiate between region and outline based forms of image segmentation
- understand the principles of motion estimation

Mid to High-Level Vision

On successful completion, students will be able to

- summarize goals and methods of tracking
- understand current approaches to image classification and retrieval
- disambiguate different tasks in object recognition, and semantic segmentation
- explain solutions to common problems in image enhancement
- appreciate current challenges in Computer Vision with respect to model training, fairness, and robustness

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Data Science & Artificial Intelligence.	All Master Programs in the IT & Technology field.

Low to Mid-Level Vision

Course Code: DLMAIWCVE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01

Course Description

This course treats subjects that belong to the low- and mid-levels of the Computer Vision hierarchy. Starting from an overview on image types, the topic of morphology is explored. Morevover, important image features like lines, edges, corners, and other points of interest will be introduced. Further, an overview on segmentation and motion inference is given.

Course Outcomes

On successful completion, students will be able to

- understand fundamental concepts in image acquisition
- know how to apply morphological operations
- describe important types of midlevel image features
- differentiate between region and outline based forms of image segmentation
- understand the principles of motion estimation

Contents

1. Image Representation & Morphology
   - 1.1 Image types (binary, grey-level, color)
   - 1.2 Morphology of Binary and Greyscale Images
2. Filtering
   - 2.1 Filtering in the Spatial Domain
   - 2.2 Fourier Transform and Filtering in the Frequency Domain
3. Mid-Level Image Features
   - 3.1 Edges & Lines
   - 3.2 Corners, Points of Interest, and Blobs
   - 3.3 Feature Based Alignment
4. Segmentation
   - 4.1 Region Based Segmentation
   - 4.2 Contour Based Segmentation

5. Motion
   - 5.1 Optical Flow
   - 5.2 Classical Approaches
   - 5.3 CNN based Methods

Literature

Compulsory Reading

Further Reading

- Davies, E.R. (2012). Computer and Machine Vision. 4th edition. Academic Press. London, Oxford, Boston, New York and San Diego.
- Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall.
- Gonzalez, R.C. , Woods, R.E. (2017): Digital Image Processing (4th edition), Prentice-Hall.
- Klette, R. (2014): Concise Computer Vision: An Introduction into Theory and Algorithms, Springer.
- Szeliski, R. (2021): Computer Vision - Algorithms and Applications, Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☐ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☑ Exam Template	☑ Slides

Mid to High-Level Vision

Course Code: DLMAIWCVE02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIWCVE01

Course Description

In this course, a thorough introduction to tracking as well as the higher-level cognitive aspects of Computer Vision like classification, recognition, and semantic segmentation is given. Moreover, the highly relevant field of image enhancement is detailed. Finally, students are sensitized to challenges in Computer Vision and current development directions to address these issues.

Course Outcomes

On successful completion, students will be able to

- summarize goals and methods of tracking
- understand current approaches to image classification and retrieval
- disambiguate different tasks in object recognition, and semantic segmentation
- explain solutions to common problems in image enhancement
- appreciate current challenges in Computer Vision with respect to model training, fairness, and robustness

Contents

1. Tracking
   - 1.1 Kalman Filters
   - 1.2 Particle Filters
   - 1.3 Tracking via Deep Networks
2. Classification
   - 2.1 Classifying Image Content
   - 2.2 Image Retrieval and Tagging
   - 2.3 Scene Understanding and Description
3. Recognition
   - 3.1 Object Recognition
   - 3.2 Semantic Segmentation
   - 3.3 Face Recognition

4. Image Synthesis
   - 4.1 Synthesizing Images and Image Enhancement
   - 4.2 Artistic Style Transfer

5. Current Challenges
   - 5.1 Vision Explainability
   - 5.2 Visual Question Answering
   - 5.3 Data Generation and Annotation

Literature

Compulsory Reading

Further Reading

- Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall.
- Goodfellow, I., Bengio, Y., Courville, A. (2016): Deep Learning. MIT Press. Cambridge, MA.
- Klette, R. (2014): Concise Computer Vision: An Introduction into Theory and Algorithms, Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

Information about the examination	
Examination Admission Requirements	**BOLK:** yes **Course Evaluation:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☑ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☑ Shortcast	☐ Live Tutorium/Course Feed
☑ Audio	☐ Reader
☐ Exam Template	☑ Slides

Master Thesis

Module Code: DLMMTHES

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	See current study and exam regulations (SPO)	MA	15	450 h

Semester / Term	Duration	Regularly offered in	Language of Instruction and Examination
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Degree Program Advisor (SGL) (Master Thesis) / Degree Program Advisor (SGL) (Colloquium)

Contributing Courses to Module

- Master Thesis (DLMMTHES01)
- Colloquium (DLMMTHES02)

Module Exam Type

Module Exam	Split Exam
	Master Thesis • Study Format "Distance Learning": Written Assessment: Master Thesis (90) • Study Format "myStudies": Written Assessment: Master Thesis (90) Colloquium • Study Format "myStudies": Presentation: Colloquium (10) • Study Format "Distance Learning": Presentation: Colloquium (10)

Weight of Module

see curriculum

Module Contents

Master Thesis

- Written Master Thesis

Colloquium

- Thesis Defense

Learning Outcomes

Master Thesis

On successful completion, students will be able to

- work on a problem from their major field of study by applying the specialist and methodological skills they have acquired during their studies.
- analyse selected tasks with scientific methods, critically evaluate them and develop appropriate solutions under the guidance of an academic supervisor.
- record and analyse existing (research) literature appropriate to the topic of the Master's thesis.
- prepare a detailed written elaboration in compliance with scientific methods.

Colloquium

On successful completion, students will be able to

- present a problem from their field of study under consideration of academic presentation and communication techniques.
- reflect on the scientific and methodological approach chosen in the Master's thesis.
- actively answer subject-related questions from subject experts (experts of the Master's thesis).

Links to other Modules within the Study Program	Links to other Study Programs of the University
All modules in the master program	All Master Programmes

Master Thesis

Course Code: DLMMTHES01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		13.5	See current study and exam regulations (SPO)

Course Description

The aim and purpose of the Master's thesis is to successfully apply the subject-specific and methodological competencies acquired during the course of study in the form of an academic dissertation with a thematic reference to the major field of study. The content of the Master's thesis can be a practical-empirical or theoretical-scientific problem. Students should prove that they can independently analyse a selected problem with scientific methods, critically evaluate it and work out proposed solutions under the subject-methodological guidance of an academic supervisor. The topic to be chosen by the student from the respective field of study should not only prove the acquired scientific competences, but should also deepen and round off the academic knowledge of the student in order to optimally align his professional abilities and skills with the needs of the future field of activity.

Course Outcomes

On successful completion, students will be able to

- work on a problem from their major field of study by applying the specialist and methodological skills they have acquired during their studies.
- analyse selected tasks with scientific methods, critically evaluate them and develop appropriate solutions under the guidance of an academic supervisor.
- record and analyse existing (research) literature appropriate to the topic of the Master's thesis.
- prepare a detailed written elaboration in compliance with scientific methods.

Contents

- Within the framework of the Master's thesis, the problem as well as the scientific research goal must be clearly emphasized. The work must reflect the current state of knowledge of the topic to be examined by means of an appropriate literature analysis. The student must prove his ability to use the acquired knowledge theoretically and/or empirically in the form of an independent and problem-solution-oriented application.

Literature
Compulsory Reading
Further Reading ▪ Bui, Y. N. (2013). How to Write a Master's Thesis (2nd ed.). SAGE Publications, Incorporated. ▪ Turabian, K. L. (2013). A Manual for Writers of Research Papers, theses, and dissertations (8th ed.). University of Chicago Press. ▪ Further subject specific literature

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Master Thesis

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
405 h	0 h	0 h	0 h	0 h	405 h

Instructional Methods

- ☐ Learning Sprints®
- ☐ Course Book
- ☐ Vodcast
- ☐ Shortcast
- ☐ Audio
- ☐ Exam Template
- ☐ Review Book
- ☐ Creative Lab
- ☑ Guideline
- ☐ Live Tutorium/Course Feed
- ☑ Slides

Study Format myStudies

Study Format	Course Type
myStudies	Thesis

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Written Assessment: Master Thesis

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
405 h	0 h	0 h	0 h	0 h	405 h

Instructional Methods	
☐ Learning Sprints®	☐ Review Book
☐ Course Book	☐ Creative Lab
☐ Vodcast	☑ Guideline
☐ Shortcast	☐ Live Tutorium/Course Feed
☐ Audio	☑ Slides
☐ Exam Template	

Colloquium

Course Code: DLMMTHES02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		1.5	See current study and exam regulations (SPO)

Course Description

The colloquium will take place after submission of the Master's thesis. This is done at the invitation of the experts. During the colloquium, the students must prove that they have fully independently produced the content and results of the written work. The content of the colloquium is a presentation of the most important work contents and research results by the student, and the answering of questions by the experts.

Course Outcomes

On successful completion, students will be able to

- present a problem from their field of study under consideration of academic presentation and communication techniques.
- reflect on the scientific and methodological approach chosen in the Master's thesis.
- actively answer subject-related questions from subject experts (experts of the Master's thesis).

Contents

- The colloquium includes a presentation of the most important results of the Master's thesis, followed by the student answering the reviewers' technical questions.

Literature

Compulsory Reading

Further Reading

- Renz, K.-C. (2016): The 1 x 1 of the presentation. For school, study and work. 2nd edition, Springer Gabler, Wiesbaden.

Study Format myStudies

Study Format	Course Type
myStudies	Thesis Defense

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Presentation: Colloquium

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
45 h	0 h	0 h	0 h	0 h	45 h

Instructional Methods

- ☐ Learning Sprints®
- ☐ Course Book
- ☐ Vodcast
- ☐ Shortcast
- ☐ Audio
- ☐ Exam Template
- ☐ Review Book
- ☐ Creative Lab
- ☑ Guideline
- ☐ Live Tutorium/Course Feed
- ☑ Slides

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis Defense

Information about the examination	
Examination Admission Requirements	**BOLK:** no **Course Evaluation:** no
Type of Exam	Presentation: Colloquium

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
45 h	0 h	0 h	0 h	0 h	45 h

Instructional Methods

- ☐ Learning Sprints®
- ☐ Course Book
- ☐ Vodcast
- ☐ Shortcast
- ☐ Audio
- ☐ Exam Template
- ☐ Review Book
- ☐ Creative Lab
- ☑ Guideline
- ☐ Live Tutorium/Course Feed
- ☑ Slides