MODULE HANDBOOK

Master of Science

Master Artificial Intelligence (FS-FI-MAAI-120-02)

120 CP

Distance Learning

As of May 14th, 2024

INTERNATIONAL
UNIVERSITY OF
APPLIED SCIENCES

Classification: Consecutive

Contents

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3. Semester

4. Semester

Module MMTHE: Master Thesis

1. Semester

Artificial Intelligence

Module Code: DLMAIAI

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. Claudia Heß (Artificial Intelligence)

Contributing Courses to Module

- Artificial Intelligence (DLMAIAI01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- History of AI
- AI application areas
- Expert systems
- Neuroscience
- Modern AI systems

Learning Outcomes	
Artificial Intelligence On successful completion, students will be able to ▪ remember the historical developments in the field of artificial intelligence. ▪ analyze the different application areas of artificial intelligence. ▪ comprehend expert systems. ▪ apply Prolog to simple expert systems. ▪ comprehend the brain and cognitive processes from a neuro-scientific point of view. ▪ understand modern developments in artificial intelligence.	
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 Programmes in the IT & Technology field

Artificial Intelligence

Course Code: DLMAIAI01

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

Course Description

The quest for artificial intelligence has captured humanity’s interest for many decades and has been an active research area since the 1960s. This course will give a detailed overview of the historical developments, successes, and set-backs in AI, as well as the development and use of expert systems in early AI systems.In order to understand cognitive processes, the course will give a brief overview of the biological brain and (human) cognitive processes and then focus on the development of modern AI systems fueled by recent developments in hard- and software. Particular focus will be given to discussion of the development of “narrow AI” systems for specific use cases vs. the creation of general artificial intelligence.The course will give an overview of a wide range of potential application areas in artificial intelligence, including industry sectors such as autonomous driving and mobility, medicine, finance, retail, and manufacturing.

Course Outcomes

On successful completion, students will be able to

- remember the historical developments in the field of artificial intelligence.
- analyze the different application areas of artificial intelligence.
- comprehend expert systems.
- apply Prolog to simple expert systems.
- comprehend the brain and cognitive processes from a neuro-scientific point of view.
- understand modern developments in artificial intelligence.

Contents

1. History of AI
   - 1.1 Historical Developments
   - 1.2 AI Winter
   - 1.3 Notable Advances in AI

2. Expert Systems
   - 2.1 Overview Over Expert Systems
   - 2.2 Introduction to Prolog

3. Neuroscience
   - 3.1 The (Human) Brain

Literature

Compulsory Reading

Further Reading

- Chowdhary, K. R. (2020). Fundamentals of Artificial Intelligence. Springer India.
- Russell, S. & Norvig, P. (2022). Artificial intelligence. A modern approach (4th ed.). Pearson Education.
- Ward, J. (2020). The student's guide to cognitive neuroscience. (4th ed.). Taylor & Francis Group.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Programming with Python

Module Code: DLMDSPWP

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

Dr. Cosmina Croitoru (Programming with Python)

Contributing Courses to Module

- Programming with Python (DLMDSPWP01)

Module Exam Type

Module Exam	Split Exam
<u>Study Format: myStudies</u> Written Assessment: Written Assignment <u>Study Format: Distance Learning</u> Written Assessment: Written Assignment	

Weight of Module

see curriculum

Module Contents

- Introduction to the Python programming language
- Object-oriented concepts in Python
- Handling of exceptions and errors
- The Python library ecosystem
- Environments and package management
- Documentation and testing
- Version control

Learning Outcomes	
Programming with Python On successful completion, students will be able to ▪ remember basic Python syntax and programming concepts. ▪ understand object-oriented concepts in Python. ▪ analyze and apply different methods for error handling in Python. ▪ know common and important Python libraries and how to apply them to given programming tasks. ▪ understand concepts like environments and version control.	
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 Programmes in the IT & Technology field

Programming with Python

Course Code: DLMDSPWP01

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

Course Description

Python is one of the most versatile and widely used scripting languages. Its clean and uncluttered syntax as well as its straightforward design greatly contribute to this success and make it an ideal language for programming education. Its application ranges from web development to scientific computing. Especially in the fields of data science and artificial intelligence, it is the most common programming language supported by all major data-handling and analytical frameworks. This course provides a thorough introduction to the language and its main features, as well as insights into the rationale and application of important adjacent concepts such as environments, testing, and version control.

Course Outcomes

On successful completion, students will be able to

- remember basic Python syntax and programming concepts.
- understand object-oriented concepts in Python.
- analyze and apply different methods for error handling in Python.
- know common and important Python libraries and how to apply them to given programming tasks.
- understand concepts like environments and version control.

Contents

1. Introduction to Python
   - 1.1 Data structures
   - 1.2 Functions
   - 1.3 Flow control
   - 1.4 Input / Output
   - 1.5 Modules & packages
2. Classes and inheritance
   - 2.1 Scopes and namespaces
   - 2.2 Classes and inheritance
   - 2.3 Iterators and generators
3. Errors and exceptions

3.1 Syntax errors
3.2 Handling and raising exceptions
3.3 User-defined exceptions

4. Important libraries
   4.1 Standard Python library
   4.2 Scientific calculations
   4.3 Speeding up Python
   4.4 Visualization
   4.5 Accessing databases

5. Working with Python
   5.1 Virtual environments
   5.2 Managing packages
   5.3 Unit and integration testing
   5.4 Documenting code

6. Version control
   6.1 Introduction to version control
   6.2 Version control with GIT

Literature

Compulsory Reading

Further Reading

- Lutz, M. (2017). Learning python (5th ed.). O'Reilly.
- Mathes, E. (2019). Python crash course. (2nd ed.). No Starch Press.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Guideline

Advanced Mathematics

Module Code: DLMDSAM-01

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. Robert Graf (Advanced Mathematics)

Contributing Courses to Module
▪ Advanced Mathematics (DLMDSAM01-01)

Module Exam Type	
Module Exam Study Format: myStudies Exam, 90 Minutes Study Format: Distance Learning Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Calculus
- Integral Transformations
- Vector Algebra
- Vector Calculus
- Matrices and Vector Spaces
- Information Theory

Learning Outcomes	
Advanced Mathematics On successful completion, students will be able to ▪ remember the fundamental rules of differentiation and integration. ▪ apply integration and differentiation techniques to vectors and vector fields. ▪ analyze matrix equations. ▪ understand the generalization of vectors to tensors. ▪ evaluate different metrics from information theoretical perspectives.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Methods	**Links to other Study Programs of the University** All Master Programmes in the Business field

Advanced Mathematics

Course Code: DLMDSAM01-01

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

Course Description

Modern techniques to analyze data and derive predictions for future events are deeply rooted in mathematical techniques.The course builds a solid base to understand the concepts behind advanced algorithms used to process, analyze, and predict data and observations and enables students to follow future research, especially in the fields of data-intensive sciences.The course reviews differentiation and integration and then discusses partial differentiation, differentiation, vector algebra and vector calculus. Matrix calculation and vector spaces are fundamental to many modern data processing algorithms and are discussed in detail. Calculations based on Tensors are introduced.Common metrics are discussed from an informational, theoretical point of view.

Course Outcomes

On successful completion, students will be able to

- remember the fundamental rules of differentiation and integration.
- apply integration and differentiation techniques to vectors and vector fields.
- analyze matrix equations.
- understand the generalization of vectors to tensors.
- evaluate different metrics from information theoretical perspectives.

Contents

1. Calculus
   - 1.1 Differentiation
   - 1.2 Integration
   - 1.3 Partial Differentiation
   - 1.4 Vector Analysis
2. Integral Transformations
   - 2.1 Convolution
   - 2.2 Complex Numbers
   - 2.3 Fourier Series
   - 2.4 Fourier Transformation
3. Vector Algebra

3.1 Scalars and Vectors
3.2 Addition and Subtraction of Vectors
3.3 Multiplication of Vectors, Vector Product, Scalar Product

4. Vector Calculus
   4.1 Differentiation of Vectors
   4.2 Integration of Vectors
   4.3 Scalar and Vector Fields
   4.4 Vector Operators

5. Matrices and Vector Spaces
   5.1 Basic Matrix Algebra and Systems of Linear Equations
   5.2 Transpose, Trace, Determinant, and Inverse of a Matrix
   5.3 Eigenvalues, Eigenvectors, and Diagonalization
   5.4 Tensors

6. Information Theory
   6.1 Mean Squared Error (MSE) and Simple Linear Regression
   6.2 Area Under the ROC Curve and Gini Index
   6.3 Entropy
   6.4 Cross Entropy

Literature

Compulsory Reading

Further Reading

- Mathai, A. M., & Haubold, H. J. (2017). Linear algebra, a course for physicists and engineers (1st ed.) De Gruyter.
- Riley, K. F., Hobson, M. P, & Bence, S. J. (2006). Mathematical methods for physics and engineering (2nd ed.). Cambridge University Press.
- Yang, X.-S. (2018). Mathematics for Civil Engineers: An Introduction. Dunedin Academic Press.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Review Book
☑ Recorded Live Sessions	☑ Slides	☑ Online Tests

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Practice Exam ☑ Review Book ☑ Online Tests

Advanced Statistics

Module Code: DLMDSAS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01	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. Paul Libbrecht (Advanced Statistics)

Contributing Courses to Module

- Advanced Statistics (DLMDSAS01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Introduction to statistics
- Important probability distributions and their applications
- Bayesian statistics
- Descriptive statistics
- Data visualization
- Parameter estimation
- Hypothesis tests

Learning Outcomes	
Advanced Statistics On successful completion, students will be able to ▪ understand the fundamental building blocks of statistics. ▪ analyze stochastic data in terms of the underlying probability distributions. ▪ utilize Bayesian statistics techniques. ▪ summarize the properties of observed data using descriptive statistics. ▪ apply data visualization techniques to design graphics that illustrate the behavior of observed data. ▪ evaluate model parameters using parameter estimation techniques. ▪ create hypothesis tests to discriminate between several model classes.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Methods	**Links to other Study Programs of the University** All Master Programmes in the Business field

Advanced Statistics

Course Code: DLMDSAS01

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

Course Description

Nearly all processes in nature and technical or scientific scenarios are not deterministic but stochastic. Therefore, these processes must be described in terms of probabilities and probability density distributions.After defining and introducing the fundamental concepts of statistics, the course will cover important probability distributions and their prevalence in application scenarios; discuss descriptive techniques to summarize and visualize data effectively; and discuss the Bayesian approach to statistics.Estimating parameters is a key ingredient in optimizing data models, and the course will give a thorough overview of the most important techniques.Hypothesis testing is a crucial aspect in establishing the observation of new effects and determination of the significance of statistical effects. Special focus will be given to the correct interpretation of p-Values and the correct procedure for multiple hypothesis tests.

Course Outcomes

On successful completion, students will be able to

- understand the fundamental building blocks of statistics.
- analyze stochastic data in terms of the underlying probability distributions.
- utilize Bayesian statistics techniques.
- summarize the properties of observed data using descriptive statistics.
- apply data visualization techniques to design graphics that illustrate the behavior of observed data.
- evaluate model parameters using parameter estimation techniques.
- create hypothesis tests to discriminate between several model classes.

Contents

1. Introduction to Statistics
   - 1.1 Random Variables
   - 1.2 Kolmogorov Axioms
   - 1.3 Probability Distributions
   - 1.4 Decomposing probability distributions
   - 1.5 Expectation Values and Moments
   - 1.6 Central Limit Theorem
   - 1.7 Sufficient Statistics
   - 1.8 Problems of Dimensionality

1.9 Component Analysis and Discriminants

2. Important Probability Distributions and their Applications
   - 2.1 Binomial Distribution
   - 2.2 Gauss or Normal Distribution
   - 2.3 Poisson and Gamma-Poisson Distribution
   - 2.4 Weibull Distribution

3. Bayesian Statistics
   - 3.1 Bayes' Rule
   - 3.2 Estimating the Prior, Benford's Law, Jeffry's Rule
   - 3.3 Conjugate Prior
   - 3.4 Bayesian & Frequentist Approach

4. Descriptive Statistics
   - 4.1 Mean, Median, Mode, Quantiles
   - 4.2 Variance, Skewness, Kurtosis

5. Data Visualization
   - 5.1 General Principles of Dataviz/Visual Communication
   - 5.2 1D, 2D Histograms
   - 5.3 Box Plot, Violin Plot
   - 5.4 Scatter Plot, Scatter Plot Matrix, Profile Plot
   - 5.5 Bar Chart

6. Parameter Estimation
   - 6.1 Maximum Likelihood
   - 6.2 Ordinary Least Squares
   - 6.3 Expectation Maximization (EM)
   - 6.4 Lasso and Ridge Regularization
   - 6.5 Propagation of Uncertainties

7. Hypothesis Test
   - 7.1 Error of 1st and 2nd Kind
   - 7.2 Multiple Hypothesis Tests
   - 7.3 p-Value

Literature
Compulsory Reading
Further Reading ▪ Bruce, P., & Bruce, A. (2017). Statistics for data scientists: 50 essential concepts. O’Reilley Publishing. ▪ Downey, A. (2013). Think Bayes. O’Reilley Publishing. ▪ Downey, A. (2014). Think stats. O’Reilley Publishing. ▪ McKay, D. (2003). Information theory, inference and learning algorithms. Cambridge University Press. ▪ Reinhart, A. (2015). Statistics done wrong. No Starch Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Review Book ☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Review Book
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Slides	☑ Guideline

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. Visieu Lac (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

<table>
<tr><td colspan="2">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.</td></tr>
<tr><td>Links to other Modules within the Study Program
This module is similar to other modules in the field of Data Science & Artificial Intelligence</td><td>Links to other Study Programs of the University
All Master Programs in the IT & Technology field</td></tr>
</table>

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

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Practice Exam ☑ Online Tests

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Project: AI Use Case

Module Code: DLMAIPAIUC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	keine	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 Study Format: myStudies Portfolio Study Format: Distance Learning Portfolio	**Split Exam**
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 field of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology field

Project: AI Use Case

Course Code: DLMAIPAIUC01

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

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.). Addison Wesley Longman.
- Nilsson, N. (2009). The quest for artificial intelligence. Cambridge University Press.
- Russel, S., & Norvig, P. (2009). Artificial intelligence: A modern approach (3rd ed.). Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

2. Semester

Advanced Research Methods

Module Code: DLMARM-01

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. Markus C. Hemmer (Advanced Research Methods)

Contributing Courses to Module

- Advanced Research Methods (DLMARM01-01)

Module Exam Type	
Module Exam Study Format: myStudies Written Assessment: Written Assignment Study Format: Distance Learning Written Assessment: Written Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Principles of Research
- Research Approaches
- The Research Project
- Selected Formal Techniques
- Selected Interpretative Topics
- Scientific Reporting

<table>
<tr><td colspan="2">Learning Outcomes

Advanced Research Methods

On successful completion, students will be able to
▪ demonstrate an understanding of principles of scientific inquiry and logical reasoning.
▪ apply formal techniques to modeling and theory generation.
▪ apply interpretative techniques to intercultural case studies.
▪ propose, plan, and conduct research projects under ethical constraints.
▪ evaluate study results to arrive at valuable and ethical conclusions.
▪ report study results responsibly in an objective and comprehensible form.</td></tr>
<tr><td>Links to other Modules within the Study Program

This module is similar to other modules in the field of Methods</td><td>Links to other Study Programs of the University

All Master Programmes in the Business field</td></tr>
</table>

Advanced Research Methods

Course Code: DLMARM01-01

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

Course Description

Advanced research methods, specifically business research, is scientific inquiry that attempts to uncover new information which helps a business improve performance, maximizing shareholder value while adhering to ethical and moral compliance standards.Managers seeking to conduct empirical research must maintain validity, reliability, and trustworthiness when utilizing scientific methodologies in order to produce meaningful and actionable results. Research proposals are typically written prior to conducting research, which have a certain structure, enabling the researcher to properly plan, conduct, and analyze case studies and surveys. Different data collection strategies are used to collect both qualitative and quantitative data, depending on the research proposal goals. Managers utilize their understanding of research methodologies to accurately assess the quality of research.

Course Outcomes

On successful completion, students will be able to

- demonstrate an understanding of principles of scientific inquiry and logical reasoning.
- apply formal techniques to modeling and theory generation.
- apply interpretative techniques to intercultural case studies.
- propose, plan, and conduct research projects under ethical constraints.
- evaluate study results to arrive at valuable and ethical conclusions.
- report study results responsibly in an objective and comprehensible form.

Contents

1. Principles of Research
   - 1.1 Scientific Inquiry
   - 1.2 Principles of Reasoning
   - 1.3 From Data to Knowledge
   - 1.4 Models & Theories
   - 1.5 The Research Cycle

2. Research Approaches
   - 2.1 Experimental Design
   - 2.2 Engineering & Development
   - 2.3 Empirical Research & Case Studies

Literature
Compulsory Reading
Further Reading ▪ Babbie, E. R. (2021). The practice of social research (15th ed.). Cengage Learning. ▪ Babbie, E. R. (2016). The practice of social research (14th ed.). Cengage Learning. ▪ Crossman, A. (2019). How to conduct an index for research. https://www.thoughtco.com/index-for-research-3026543 ▪ Eurostat. (n.d.). Beginners: Statistical concept - Index and base year. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Beginners:Statistical_concept_-_Index_and_base_year ▪ Giles, D. (2004). Advanced research methods in psychology (Reprint). Psychology Press. ▪ Rea, L.M., & Parker, R.A. (2014). Designing and conducting survey research: A comprehensive guide, (4th ed). Jossey-Bass. ▪ Saunders, M., Thornhill, A., & Lewis, P. (2019). Research methods for business students (8th ed). Pearson. ▪ Takahashi, A. R. W., & Araujo, L. (2019). Case study research: Opening up research opportunities. RAUSP Management Journal, 55(1), 100–111. ▪ Widner, J., Woolcock, M., & Ortega Nieto, D. (Eds.). (2022). The case for case studies: Methods and applications in international development (strategies for social inquiry). Cambridge University Press.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

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. Visieu Lac (Deep Learning)

Contributing Courses to Module
▪ Deep Learning (DLMDSDL01)

Module Exam Type	
Module Exam Study Format: myStudies Oral Assignment Study Format: Distance Learning Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Introduction to neural networks and deep learning
- 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 field of Data Science & Artificial Intelligence	All Master Programs in the IT & Technology field

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. (2021). Deep learning with Python (2nd ed.). Manning Publications.
- Geron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow (3rd ed.). O'Reilly Media Inc.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.
- Russel, S., & Norvig, P. (2022). Artificial intelligence – A modern approach (4th ed.). Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video	**Exam Preparation** ☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload

Self Study	Contact Hours	Tutorial/Tutorial Support	Self Test	Independent Study	Hours Total
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods

Tutorial Support	Learning Material	Exam Preparation
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book	☑ Online Tests ☑ Guideline

Continual Learning with Neural Networks

Module Code: DLMAICLNN

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSPWP01, DLMDSML01, DLMDSDL01	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. Betram Taetz (Continual Learning with Neural Networks)

Contributing Courses to Module
▪ Continual Learning with Neural Networks (DLMAICLNN01)

Module Exam Type	
Module Exam <u>Study Format: Distance Learning</u> Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

- lifelong machine learning
- neural networks
- stability plasticity dilemma
- catastrophic interference
- continual learning using Python

Learning Outcomes	
Continual Learning with Neural Networks On successful completion, students will be able to ▪ explain the fundamental principles of lifelong machine learning. ▪ analyze the stability-plasticity dilemma in neural networks. ▪ implement strategies to mitigate catastrophic interference. ▪ apply continual learning principles across different application domains. ▪ develop continual learning models in Python. ▪ evaluate the efficacy of neural network models in lifelong learning.	
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

Continual Learning with Neural Networks

Course Code: DLMAICLNN01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSPWP01, DLMDSML01, DLMDSDL01

Course Description

In this course, students learn about the lifelong machine learning paradigm that trains neural network models on sequential tasks. Students will gain experience in overcoming catastrophic forgetting, adaptability to new tasks, and preserving knowledge over time. The topics include lifelong learning strategies, typical neural network architectures for continual learning, and practical applications in domains like computer vision, natural language processing, and more. This course equips students with skills to develop AI systems that can continuously learn and adapt in dynamic environments.

Course Outcomes

On successful completion, students will be able to

- explain the fundamental principles of lifelong machine learning.
- analyze the stability-plasticity dilemma in neural networks.
- implement strategies to mitigate catastrophic interference.
- apply continual learning principles across different application domains.
- develop continual learning models in Python.
- evaluate the efficacy of neural network models in lifelong learning.

Contents

1. Understanding Lifelong Machine Learning
   - 1.1 The Evolution of Machine Learning Paradigms
   - 1.2 Defining Lifelong Learning in Neural Networks
   - 1.3 Key Characteristics of Lifelong Learning Systems
   - 1.4 Comparing Lifelong, Transfer, and Multi-task Learning

2. The Stability-Plasticity Dilemma and Catastrophic Forgetting
   - 2.1 Understanding the Stability-Plasticity Trade-off
   - 2.2 Catastrophic Forgetting: Implications for Neural Networks
   - 2.3 Biological Insights into Overcoming Catastrophic Forgetting

3. Strategies to Overcome Catastrophic Interference
   - 3.1 Regularization Techniques for Lifelong Learning

Literature

Compulsory Reading

Further Reading

- Chen, Z., & Liu, B. (2018). *Lifelong Machine Learning*. Springer International Publishing.
- Ermis, B., Zappella, G., Wistuba, M., Rawal, A., & Archambeau, C. (2022). Memory Efficient Continual Learning with Transformers. In S. Koyejo, S. Mohamed, A. Agarwal, D. Belgrave, K. Cho, & A. Oh (Hrsg.), *Advances in Neural Information Processing Systems* (Bd. 35, S. 10629–10642). Curran Associates, Inc.
- Parisi, G. I., Kemker, R., Part, J. L., Kanan, C., & Wermter, S. (2019). Continual lifelong learning with neural networks: A review. *Neural Networks*, *113*, 54–71.
- Van De Ven, G. M., Siegelmann, H. T., & Tolias, A. S. (2020). Brain-inspired replay for continual learning with artificial neural networks. *Nature Communications*, *11*(1), 4069.
- Wang, L., Zhang, X., Su, H., & Zhu, J. (2024). A Comprehensive Survey of Continual Learning: Theory, Method and Application. *IEEE Transactions on Pattern Analysis and Machine Intelligence*, 1–20.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Ses-sions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video	☑ Online Tests ☑ Guideline

Seminar: AI and Society

Module Code: DLMAISAIS

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: AI and Society)

Contributing Courses to Module

- Seminar: AI and Society (DLMAISAIS01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

In this module, students will reflect on current societal and political implications of artificial intelligence. 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: AI and Society On successful completion, students will be able to ▪ name selected current societal topics and issues in artificial intelligence. ▪ explain the influence and impact of artificial intelligence on societal, economic, and polital topics. ▪ transfer theoretically-acquired knowledge to real-world cases. ▪ treat in a scientific manner a select topic in the form of a written essay. ▪ critically question and discuss current societal and political issues arising from the recent advances in artificial intelligence methodology. ▪ develop own problem-solving skills and processes through reflection on the possible impact of their future occupation in the sector of artificial intelligence.	
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 Programmes in the IT & Technology field

Seminar: AI and Society

Course Code: DLMAISAIS01

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

Course Description

In the current decade, impressive advances have been achieved in the field of artificial intelligence. Several cognitive tasks like object recognition in images and video, natural language processing, game strategy, and autonomous driving and robotics are now being performed by machines at unprecedented levels of ability. This course will examine some of societal, economic, and political implications of these developments.

Course Outcomes

On successful completion, students will be able to

- name selected current societal topics and issues in artificial intelligence.
- explain the influence and impact of artificial intelligence on societal, economic, and polital topics.
- transfer theoretically-acquired knowledge to real-world cases.
- treat in a scientific manner a select topic in the form of a written essay.
- critically question and discuss current societal and political issues arising from the recent advances in artificial intelligence methodology.
- develop own problem-solving skills and processes through reflection on the possible impact of their future occupation in the sector of artificial intelligence.

Contents

- The seminar covers current topics concerning the societal impact of artificial intelligence. Each participant must create a seminar paper on a topic assigned to him/her. A current list of topics is given in the Learning Management System.

Literature
Compulsory Reading
Further Reading ▪ Bailey, S. J. (2020). Academic writing for international students of business and economics (Third edition). Routledge. ▪ Day, T. (2018). Success in academic writing. (2nd ed.). ▪ Fang, Z. (2021). Demystifying academic writing: genres, moves, skills, and strategies. Routledge, Taylor & Francis Group. ▪ Silvia, P. J. (2019). How to write a lot: a practical guide to productive academic writing (2nd ed.). American Psychological Association.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Software Engineering for Data Intensive Sciences

Module Code: DLMDSSEDIS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	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. Max Pumperla (Software Engineering for Data Intensive Sciences)

Contributing Courses to Module

- Software Engineering for Data Intensive Sciences (DLMDSSEDIS01)

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

- Agile project management
- DevOps
- Software development
- API
- From model to production

Learning Outcomes	
Software Engineering for Data Intensive Sciences On successful completion, students will be able to ▪ understand the agile approaches Scrum and Kanban. ▪ explain how DevOps brings software development and operations together into one team. ▪ write high-quality code using relevant software development techniques. ▪ evaluate the requirements for APIs. ▪ create APIs for software applications. ▪ identify the challenges of bringing a model into production.	
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 Programmes in the IT & Technology field

Software Engineering for Data Intensive Sciences

Course Code: DLMDSSEDIS01

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

Course Description

Building a successful data-based product requires a significant amount of high-quality code which needs to run in a professional production environment. This course starts by introducing the agile approaches Scrum and Kanban and then discusses the shift from more traditional software development approaches to the DevOps culture.Special focus is given to the discussion and understanding of techniques and approaches for producing high-quality code such as unit and integration testing, test-driven development, pair programing, and continuous delivery and integration.Since many software artefacts are accessed via APIs, this course introduces concepts of API design and paradigms.Finally, this course addresses the challenges of bringing code into a production environment, building a scalable environment, and using cloud-cased approaches.

Course Outcomes

On successful completion, students will be able to

- understand the agile approaches Scrum and Kanban.
- explain how DevOps brings software development and operations together into one team.
- write high-quality code using relevant software development techniques.
- evaluate the requirements for APIs.
- create APIs for software applications.
- identify the challenges of bringing a model into production.

Contents

1. Agile Project Management
    - 1.1 Introduction to SCRUM
    - 1.2 Introduction to Kanban

2. DevOps
    - 2.1 Traditional lifecycle management
    - 2.2 Bringing development and operations together
    - 2.3 Impact of team structure
    - 2.4 Building a DevOps infrastructure

3. Software Development
    - 3.1 Unit & integration test, performance monitoring

3.2 Test-driven development & pair programing
3.3 Continuous delivery & integration
3.4 Overview of relevant tools

4. API
4.1 API design
4.2 API paradigms

5. From Model to Production
5.1 Building a scalable environment
5.2 Model versioning and persistence
5.3 Cloud-based approaches

Literature

Compulsory Reading

Further Reading

- Farcic, V. (2016). The DevOps 2.0 toolkit: Automating the continuous deployment pipeline with containerized microservices. CreateSpace Independent Publishing Platform.
- Kelleher, A. & Kelleher, A. (2019). Machine learning in production: Developing and optimizing data science workflows and applications. Addison-Wesley.
- Kerzner, H. (2017). Project Management - A Systems Approach to Planning, Scheduling, and Controlling (12th ed., pp. 74—75). John Wiley & Sons.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

NLP and Computer Vision

Module Code: DLMAINLPCV

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. Tim Schlippe (NLP and Computer Vision)

Contributing Courses to Module

- NLP and Computer Vision (DLMAINLPCV01)

Module Exam Type	
Module Exam Study Format: Distance Learning Oral Assignment Study Format: myStudies Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

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

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.	
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 Programmes in the IT & Technology field

NLP and Computer Vision

Course Code: DLMAINLPCV01

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

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Reinforcement Learning

Module Code: DLMAIRIL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSPWP01, DLMDSML01, DLMDSDL01	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. Max Pumperla (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 field of Data Science & Artificial Intelligence	All Master Programs in the IT & Technology field

Reinforcement Learning

Course Code: DLMAIRIL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01, DLMDSPWP01, DLMDSML01, DLMDSDL01

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Inference and Causality

Module Code: DLMAIIAC

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSAS01, 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. Bertram Taetz (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 This module is similar to other modules in the field of Data Science & Artificial Intelligence	**Links to other Study Programs of the University** All Master Programmes in the IT & Technology field

Inference and Causality

Course Code: DLMAIIAC01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01, DLMDSAS01, DLMDSPWP01

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Advanced Workbook

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Explainable and Interpretable Machine Learning Models

Module Code: DLMMLEIMLM

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	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
Dr. Maja Popovic (Explainable and Interpretable Machine Learning Models)

Contributing Courses to Module
▪ Explainable and Interpretable Machine Learning Models (DLMMLEIMLM01)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Explainability
- Accoutability
- Interpretability
- Trustworthy AI

Learning Outcomes	
Explainable and Interpretable Machine Learning Models On successful completion, students will be able to ▪ understand the meaning of model explainability and interpretability and their importance for managing biases in the predictions generated by ML models. ▪ judge the reliability of ML models in generating predictions in different use cases. ▪ know frameworks such as Lime, SHAP, Skater, ELI5, etc. and be aware of their shortcomings. ▪ understand regulatory frameworks that address trustworthiness of AI-systems. ▪ analyze state-of-the-art explainability research.	
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

Explainable and Interpretable Machine Learning Models

Course Code: DLMMLEIMLM01

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

Course Description

In this course students learn about model explainability and interpretability basics, ethical considerations and biases in the predictions generated by AI models. Also, they learn about the reliability of AI models in generating predictions in different use cases. A broad overview highlighting ante-hoc and post-hoc explainability methods, including their shortcomings will be provided. They will know methods and systems to interpret the models that are used in AI, such as non-linear models and time series models. They will know frameworks such as Lime, SHAP, Skater, ELI5, etc. for complex ensemble models, explainability, and interpretability. They will also know about model explainability for unstructured data and natural language processing-related tasks.

Course Outcomes

On successful completion, students will be able to

- understand the meaning of model explainability and interpretability and their importance for managing biases in the predictions generated by ML models.
- judge the reliability of ML models in generating predictions in different use cases.
- know frameworks such as Lime, SHAP, Skater, ELI5, etc. and be aware of their shortcomings.
- understand regulatory frameworks that address trustworthiness of AI-systems.
- analyze state-of-the-art explainability research.

Contents

1. Foundations of Explainable AI (XAI)
   - 1.1 Understanding the need for transparency in AI decision-making
   - 1.2 An overview of explainability and interpretability: meaning and limitations
   - 1.3 The Blackbox problem
   - 1.4 Introduction to model complexity, interpretability, and trade-offs

2. Bias in AI Systems
   - 2.1 Identifying sources of bias in data, algorithms, and model deployment and evaluation
   - 2.2 Analyzing the impact of bias on decision-making and fairness
   - 2.3 Mitigation techniques for reducing bias in AI models.

- 2.4 Data quality assessments
- 2.5 Alternative metrics and assurance for model reliability

3. Interpretability Techniques
   - 3.1 Overview of model-agnostic and model-specific interpretability methods
   - 3.2 Feature importance analysis, SHAP values, and LIME explanations
   - 3.3 Visualizing complex models using tools like decision trees and attention maps
   - 3.4 Unresolved issues and challenges of explainability methods
   - 3.5 Implementing explainability methods in real-world scenarios

4. Ethical Considerations in explainability
   - 4.1 Ethical dilemmas in explainability and how to mitigate them
   - 4.2 Challenges related to transparency, accountability, and trustworthiness of AI systems
   - 4.3 Strategies for addressing privacy concerns while maintaining transparency
   - 4.4 The impact of explainability and trustworthy AI on society

5. Regulatory aspects for implementing explainability
   - 5.1 Regulatory guidelines and standards for ensuring to explainability and fairness in AI decision-making processes
   - 5.2 The need for accountability of different end users and sectors
   - 5.3 Mandates for organizations to provide interpretable explanations for AI-generated outcomes
   - 5.4 Reporting and documentation requirements for AI systems, including model architecture, data sources, and decision rules
   - 5.5 Implications of explainability regulations on critical sectors such as finance, healthcare, and criminal justice.

6. Research trends and future considerations
   - 6.1 Interactive XAI methods for engaging users in the decision-making process
   - 6.2 Human-AI collaboration models for enhanced user trust
   - 6.3 Transferability of explanations between different domains and tasks
   - 6.4 Context adaptable algorithms considering different user contexts and application scenarios.
   - 6.5 Combining model-agnostic and model-specific interpretability techniques for hybrid models

Literature
Compulsory Reading
Further Reading ▪ Du, M., Liu, N., & Hu, X. (2019). Techniques for interpretable machine learning. Communications of the ACM, 63(1), 68-77. ▪ Gilpin, L. H., Bau, D., Yuan, B. Z., Bajwa, A., Specter, M., & Kagal, L. (2018, October). Explaining explanations: An overview of interpretability of machine learning. In 2018 IEEE 5th International Conference on data science and advanced analytics (DSAA) (pp. 80-89). IEEE. ▪ Mueller, S. T., Hoffman, R. R., Clancey, W., Emrey, A., & Klein, G. (2019). Explanation in human-AI systems: A literature meta-review, synopsis of key ideas and publications, and bibliography for explainable AI. arXiv preprint arXiv:1902.01876. ▪ Spinner, T., Schlegel, U., Schäfer, H., & El-Assady, M. (2019). explAIner: A visual analytics framework for interactive and explainable machine learning. IEEE transactions on visualization and computer graphics, 26(1), 1064-1074.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Review Book
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Slides	☑ Guideline

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 field of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology field

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 ▪ Bailey, S. J. (2020). Academic writing for international students of business and economics (3rd ed.). Routledge. ▪ Day, T. (2018). Success in academic writing. (2nd ed.) ▪ Fang, Z. (2021). Demystifying academic writing: genres, moves, skills, and strategies. Routledge, Taylor & Francis Group. ▪ Silvia, P. J. (2019). How to write a lot: a practical guide to productive academic writing (2nd ed.). American Psychological Association.

Study Format myStudies

Study Format	Course Type
myStudies	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Natural Language Processing

Module Code: DLMAIWNLPVA1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01	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. Anne Schwerk (Natural Language Processing)

Contributing Courses to Module

- Natural Language Processing (DLMAIWNLPVA01)

Module Exam Type

Module Exam	Split Exam
<u>Study Format: myStudies</u> Oral Assignment <u>Study Format: Distance Learning</u> Oral Assignment	

Weight of Module

see curriculum

Module Contents

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

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.	
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 myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload

Self Study	Contact Hours	Tutorial/Tutorial Support	Self Test	Independent Study	Hours Total
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods

Tutorial Support	Learning Material	Exam Preparation
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Project: Prompt Engineering

Module Code: DLMMLPPE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMAIWNLPVA01 or DLMAIWNLPVA01_D	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. Florian Schneider (Project: Prompt Engineering)

Contributing Courses to Module
▪ Project: Prompt Engineering (DLMMLPPE01)

Module Exam Type	
Module Exam Study Format: Distance Learning Portfolio	**Split Exam**
Weight of Module see curriculum	

Module Contents
In this project course the students work on a practical implementation of an artificial intelligence use case of their choosing, applying prompt engineering to guide the large language model (LLM) to provide the desired results. All relevant artifacts like use case evaluation, chosen implementation pipeline or architecture, prompts, and outcomes are to be documented.

Learning Outcomes	
Project: Prompt Engineering On successful completion, students will be able to ▪ analyze and critique existing prompt engineering practices and optimize prompts with innovative strategies. ▪ know prompt engineering/techniques and tactics to build reliable systems based on LLMs. ▪ know prompt engineering tools like LangChain, DUST or OpenAI Python client. ▪ apply advanced prompt engineering techniques like e.g., Few-Shot learning, chain-of-thought. ▪ identify and delineate potential uses for the chosen topic's concepts. ▪ discuss safety concerns with the usage of user data in prompts like prompt-injection.	
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

Project: Prompt Engineering

Course Code: DLMMLPPE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMAIWNLPVA01 or DLMAIWNLPVA01_D

Course Description

The project-based course is centered around the development and enhancement of conversational AI models, with a specific focus on prompts. Prompt engineering allows to program conversational large language models (LLMs), as the quality of the output generated by a conversational LLM is directly related to the quality of the prompts provided by the user. Hence the more specific and tailored prompts are, the better the outcomes. The course will explore the significance of prompts in maintaining conversation, improving language model output, and strategies to engineer effective prompts. In this course students will gain the theoretical knowledge, relevant tools and the practical experience to meticulously and creatively design, test, and refine prompts for a range of applications.

Course Outcomes

On successful completion, students will be able to

- analyze and critique existing prompt engineering practices and optimize prompts with innovative strategies.
- know prompt engineering/techniques and tactics to build reliable systems based on LLMs.
- know prompt engineering tools like LangChain, DUST or OpenAI Python client.
- apply advanced prompt engineering techniques like e.g., Few-Shot learning, chain-of-thought.
- identify and delineate potential uses for the chosen topic's concepts.
- discuss safety concerns with the usage of user data in prompts like prompt-injection.

Contents

- Students will acquire practical knowledge on how to engineer prompts, including zero-shot and few-shot prompts, self-adapting prompts, text-to-image engineering, and specialized domain prompts. Also, ethical concerns will be highlighted, such as malicious prompts and jailbreaking scenarios. Students will learn prompt selection strategies based on different contexts, how to design outputs for different formats, and how to correct errors. Also, different types of prompt architectures and prompt engineering techniques for specific domains to build domain specific apps will be covered. Students will explore innovative concepts such as "Flipped Interaction" and "Game Play," to obtain high-quality outcomes. Versatile tools and meta language creation patterns for advanced prompt engineering will be explored and students will gain the skills for crafting effective prompts that shape AI interactions while also navigating ethical challenges.

Literature
Compulsory Reading
Further Reading ▪ White, J., Fu, Q., Hays, S., Sandborn, M., Olea, C., Gilbert, H., ... & Schmidt, D. C. (2023). A prompt pattern catalog to enhance prompt engineering with chatgpt. arXiv preprint arXiv:2302.11382. ▪ Wang, J., Shi, E., Yu, S., Wu, Z., Ma, C., Dai, H., ... & Zhang, S. (2023). Prompt engineering for healthcare: Methodologies and applications. arXiv preprint arXiv:2304.14670. ▪ Liu, Y., Deng, G., Xu, Z., Li, Y., Zheng, Y., Zhang, Y., ... & Liu, Y. (2023). Jailbreaking chatgpt via prompt engineering: An empirical study. arXiv preprint arXiv:2305.13860. ▪ Liu, V., & Chilton, L. B. (2022, April). Design guidelines for prompt engineering text-to-image generative models. In Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems (pp. 1-23).

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Exam Preparation** ☑ Guideline

Voice Assistants

Module Code: DLMAIWNLPVA2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01	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. Anne Schwerk (Voice Assistants)

Contributing Courses to Module

- Voice Assistants (DLMAIWNLPVA02)

Module Exam Type	
Module Exam Study Format: myStudies Portfolio Study Format: Distance Learning Portfolio	**Split Exam**
Weight of Module see curriculum	

Module Contents

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

Learning Outcomes	
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.

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 myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Image Processing and Low Level Vision

Module Code: DLMAIWFCV1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01	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. Konstantinos Amplianitis (Image Processing and Low Level Vision)

Contributing Courses to Module

- Image Processing and Low Level Vision (DLMAIWFCV01)

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

- Image Acquisition
- Single and Multi-View Geometry
- Image Representation and Morphology
- Filtering
- Texture

Learning Outcomes	
Image Processing and Low Level Vision On successful completion, students will be able to ▪ understand fundamental concepts in image acquisition. ▪ compare different approaches to establish the image geometry. ▪ recognize different image types. ▪ know how to apply morphological operations. ▪ explain image filtering in the spatial and frequency. ▪ summarize common approaches to texture representation.	
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

Image Processing and Low Level Vision

Course Code: DLMAIWFCV01

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

Course Description

Computer vision is generally understood as a subfield of artificial intelligence and primarily concerned with developing and researching methods that enable computers to gain a high-level understanding of images or videos. This allows computers to perform high level visual cognitive tasks, emulating or even surpassing the human capability to derive information from visual input.This course provides an exposition to the foundational aspects from the domain of image processing which underly many of the more cognitive oriented approaches of computervision.Starting from an overview on image acquisition the topic of image geometry is explored. Subsequently, common digital image representations are introduced together with basic morphological operations on them. The course closes with an introduction to filtering and texture representation.

Course Outcomes

On successful completion, students will be able to

- understand fundamental concepts in image acquisition.
- compare different approaches to establish the image geometry.
- recognize different image types.
- know how to apply morphological operations.
- explain image filtering in the spatial and frequency.
- summarize common approaches to texture representation.

Contents

1. Image Acquisition
   - 1.1 The Human Visual System
   - 1.2 Cameras and Sensors
2. Single and Multi-View Geometry
   - 2.1 Camera Geometry and Perspective Projection
   - 2.2 Stereopsis and Multiple Views
3. Image Representation and Morphology
   - 3.1 Image Types
   - 3.2 Morphology of Binary and Greyscale Images

4. Filtering
   - 4.1 Filtering in the Spatial Domain
   - 4.2 Fourier Transformation and Filtering in the Frequency Domain

5. Texture
   - 5.1 Classical Texture Representations
   - 5.2 Bag of Words and Representation in CNNs

Literature

Compulsory Reading

Further Reading

- Forsyth, D., Ponce, J. (2012). Computer Vision - A Modern Approach. Prentice Hall.
- Gonzalez, R.C., Woods, R.E. (2017). Digital Image Processing (4th ed.). Prentice Hall.
- Hartley, R., Zisserman, A. (2004). Multiple View Geometry in Computer Vision (2nd ed.). Cambridge University Press.
- Klette, R. (2014). Concise Computer Vision: An Introduction into Theory and Algorithms. Springer.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Mid-Level Vision and Video

Module Code: DLMAIWFCV2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01	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. Konstantinos Amplianitis (Mid-Level Vision and Video)

Contributing Courses to Module
▪ Mid-Level Vision and Video (DLMAIWFCV02)

Module Exam Type	
Module Exam Study Format: Distance Learning Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Mid-Level Image Features
- Segmentation
- Motion
- Tracking
- Shape

Learning Outcomes	
Mid-Level Vision and Video On successful completion, students will be able to ▪ describe important types of midlevel image features. ▪ differentiate between region and outline based forms of image segmentation. ▪ understand the principles of motion estimation. ▪ explain different approaches to object tracking. ▪ appraise the role of shape in image understanding. ▪ remember the most common approaches to shape inference.	
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.

Mid-Level Vision and Video

Course Code: DLMAIWFCV02

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

Course Description

Computer vision is generally understood as a subfield of artificial intelligence and primarily concerned with developing and researching methods that enable computers to gain a high-level understanding of images or videos. This allows computers to perform high level visual cognitive tasks, emulating or even surpassing the human capability to derive information from visual input.This course treats subjects that belong to the mid-level of the Computer Vision hierarchy. As such, it forms the bridge from low-level image processing to high-level computer vision. In particular, important image features like lines, edges, corners and other points of interest will be introduced. Based on this,an overview on segmentation and shape inference is given. Moreover, in the course the relevant topics of motion estimation and tracking are covered.

Course Outcomes

On successful completion, students will be able to

- describe important types of midlevel image features.
- differentiate between region and outline based forms of image segmentation.
- understand the principles of motion estimation.
- explain different approaches to object tracking.
- appraise the role of shape in image understanding.
- remember the most common approaches to shape inference.

Contents

1. Mid-Level Image Features
   - 1.1 Edges & Lines
   - 1.2 Corners, Points of Interest, and Blobs
   - 1.3 Feature Based Alignment

2. Segmentation
   - 2.1 Region Based Segmentation
   - 2.2 Contour Based Segmentation

3. Motion
   - 3.1 Optical Flow
   - 3.2 Classical Approaches

Literature

Compulsory Reading

Further Reading

- Davies, E.R. (2012). Computer and Machine Vision. (4th ed.). Academic Press.
- Forsyth, D., Ponce, J. (2012). Computer Vision - A Modern Approach. Prentice Hall.
- Klette, R. (2014). Concise Computer Vision: An Introduction into Theory and Algorithms. Springer.
- Szeliski, R. (2010). Computer Vision - Algorithms and Applications. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Project: Generative Deep Learning

Module Code: DLMAIPGDL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSDL01 or DLMDWDL01	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. Bertram Taetz (Project: Generative Deep Learning)

Contributing Courses to Module

- Project: Generative Deep Learning (DLMAIPGDL01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Project Report	

Weight of Module

see curriculum

Module Contents

This project-based course emphasizes hands-on experience, and students work on practical aspects of generative deep learning. 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.

Learning Outcomes	
Project: Generative Deep Learning On successful completion, students will be able to ▪ understand the fundamental principles of generative modeling and discriminate between generative and discriminative models. ▪ explore and apply diffusion models in generative tasks. ▪ leverage generative models for creative applications in text, image, and audio generation. ▪ develop multimodal models that can generate or manipulate data across different domains. ▪ troubleshoot common challenges and understand the limitations of generative deep learning models. ▪ critically assess the ethical implications and responsibilities associated with deploying generative models. ▪ design, implement, and train Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) for various data types.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Data Science & Artificial Intelligence	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Project: Generative Deep Learning

Course Code: DLMAIPGDL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSDL01 or DLMDWDL01

Course Description

In this course, students will gain hands-on experience creating and using generative models based on deep neural networks. Through hands-on projects, participants will explore and implement state-of-the-art techniques like Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), and diffusion models. The course is designed to equip learners with the knowledge and skills to create complex generative models capable of producing high-quality outputs across various domains, including but not limited to image, text, and audio generation. By delving into example implementations in Python and utilizing popular deep-learning frameworks, students will gain the experience needed to tackle real-world generative modeling challenges.

Course Outcomes

On successful completion, students will be able to

- understand the fundamental principles of generative modeling and discriminate between generative and discriminative models.
- explore and apply diffusion models in generative tasks.
- leverage generative models for creative applications in text, image, and audio generation.
- develop multimodal models that can generate or manipulate data across different domains.
- troubleshoot common challenges and understand the limitations of generative deep learning models.
- critically assess the ethical implications and responsibilities associated with deploying generative models.
- design, implement, and train Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) for various data types.

Contents

- In this advanced course, students will delve into the intricacies of generative deep learning by developing and applying cutting-edge models such as Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), and diffusion models. Emphasizing a project-based and hands-on approach, participants will learn to generate high-quality synthetic data across diverse modalities, including imagery, textual content, and audio, using Python and renowned deep-learning libraries. The course is structured around practical projects, encouraging students to document their exploration and mastery of generative models through comprehensive project reports that detail their methodology, codebase, and the evaluation of generated outcomes against real-world benchmarks.

Literature
Compulsory Reading
Further Reading ▪ Foster, D., & Friston, K. J. (2023). Generative deep learning: Teaching machines to paint, write, compose, and play (2nd ed.). O'Reilly. ▪ Oussidi, A., & Elhassouny, A. (2018). Deep generative models: Survey. 2018 International Conference on Intelligent Systems and Computer Vision (ISCV), 1–8. ▪ Tomczak, J. M. (2022). Deep Generative Modeling. Springer International Publishing. ▪ Yang, L., Zhang, Z., Song, Y., Hong, S., Xu, R., Zhao, Y., Zhang, W., Cui, B., & Yang, M.-H. (2024). Diffusion Models: A Comprehensive Survey of Methods and Applications. ACM Computing Surveys, 56(4), 1–39.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods	
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Exam Preparation** ☑ Guideline

Concepts of FinTechs and Artificial Intelligence

Module Code: DLMAIEFT1

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. Stefan Tilch (Concepts of FinTechs and Artificial Intelligence)

Contributing Courses to Module
▪ Concepts of FinTechs and Artificial Intelligence (DLMAIEFT01)

Module Exam Type	
Module Exam Study Format: myStudies Exam or Written Assessment: Written Assignment, 90 Minutes Study Format: Distance Learning Exam or Written Assessment: Written Assignment, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- 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

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.

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 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

Literature

Compulsory Reading

Further Reading

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

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Written Assignment, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Written Assignment, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Practice Exam ☑ Online Tests

Corporate Governance of IT, Compliance, and Law

Module Code: DLMIGCR-01_E

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

Johannes Kent Walter (Corporate Governance of IT, Compliance, and Law)

Contributing Courses to Module

- Corporate Governance of IT, Compliance, and Law (DLMIGCR01-01_E)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- IT Governance: Motivation and Challenges
- COBIT Framework
- IT Compliance
- IT basic protection according to BSI IT law

Learning Outcomes	
Corporate Governance of IT, Compliance, and Law On successful completion, students will be able to ▪ explain the terms IT governance and IT compliance. ▪ categorize typical processes and activities from the area of IT governance and IT compliance. ▪ give an overview of the COBIT framework and its elements. ▪ give an overview of IT-Governance and explain its structure. ▪ reproduce important laws and regulations in the field of IT law and explain their areas of application.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Computer Science & Software Development	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Corporate Governance of IT, Compliance, and Law

Course Code: DLMIGCR01-01_E

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

Course Description

In this course, students learn terms and frameworks related to IT governance and IT compliance. First, a short introduction and an overview of the different aspects of IT governance and IT compliance are given; then, COBIT and IT basic protection are explained as two frameworks that are used in industrial practice. In addition, this course will introduce and discuss important legal frameworks and standards related to IT law.

Course Outcomes

On successful completion, students will be able to

- explain the terms IT governance and IT compliance.
- categorize typical processes and activities from the area of IT governance and IT compliance.
- give an overview of the COBIT framework and its elements.
- give an overview of IT-Governance and explain its structure.
- reproduce important laws and regulations in the field of IT law and explain their areas of application.

Contents

1. IT Governance: Motivation and Challenges
   - 1.1 Governance and IT Governance
   - 1.2 Frameworks for IT Governance
   - 1.3 Typical IT Governance, Service Management, and Security Frameworks and Standards

2. COBIT Framework
   - 2.1 Overview of the Elements of COBIT
   - 2.2 Governance and Management Objectives
   - 2.3 Use of COBIT and COBIT Design Factors
   - 2.4 The Target Cascade of COBIT

3. IT Compliance
   - 3.1 Introduction to IT Compliance
   - 3.2 Examples of National and International Guidelines: Risk Management Standards and Frameworks

	3.3 IT Compliance: Typical Measures
4.	Basic IT Protection According to BSI
	4.1 Overview and Structure
	4.2 Approach to IT Security Governance
	4.3 Usage Example of IT Security Governance
5.	Introduction to IT Service Management
	5.1 What is Information Technology Service Management?
	5.2 What is ITIL® V4?
	5.3 What is ISO/IEC 20000-1:2018?
	5.4 Other ITSM Frameworks and Standards
6.	IT Law
	6.1 Overview of Relevant Laws
	6.2 Protection of Intellectual Property
	6.3 IT Contracts
	6.4 Privacy

Literature

Compulsory Reading

Further Reading

- Cervone, H. F. (2017). Implementing IT governance: A primer for informaticians. Digital Library Perspectives, 33(4), 282—287.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Practice Exam ☑ Online Tests

3. Semester

Fraud Detection FinTechs

Module Code: DLMAIEFT2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEFT01	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. Manuela Ender (Fraud Detection FinTechs)

Contributing Courses to Module

- Fraud Detection FinTechs (DLMAIEFT02)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- 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

<table>
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Learning Outcomes

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.

</td></tr>
<tr><td>

Links to other Modules within the Study Program

This module is similar to other modules in the field of Finance & Tax Accounting

</td><td>

Links to other Study Programs of the University

All Master Programs in the Business field

</td></tr>
</table>

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

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.
- Ashfaq, M. and Randall, V.J. (2020). Wirecard: The rise and fall of a German FinTech, The Case Centre.
- Boobier, T. (2020). AI and the future of banking. John Wiley & Sons Ltd.
- Gough, L. (2021). The CON men: a history of financial fraud and the lessons you can learn. Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

AI in Production

Module Code: DLMAIEIAI1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01	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

Martin Ejeagwu (AI in Production)

Contributing Courses to Module

- AI in Production (DLMAIEIAI01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

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

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.	
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 and Their Deployment in a Smart Factory
    - 1.5 Major Security Concerns in a Smart Factory
    - 1.6 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 AI Techniques for Autonomous Planning and Scheduling
   - 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. 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. Springer International Publishing. https://doi.org/10.1007/978-3-030-66222-6

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

Project: Industrial Internet of Things

Module Code: DLMAIEIAI2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIEIAI01	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

Dr. Cosmina Croitoru (Project: Industrial Internet of Things)

Contributing Courses to Module

- Project: Industrial Internet of Things (DLMAIEIAI02)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Oral Project Report Study Format: Distance Learning Oral Project Report	

Weight of Module

see curriculum

Module 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.

Learning Outcomes	
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

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 myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Oral Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Oral Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Introduction to AI in E-Commerce and Marketing

Module Code: DLMAIEECMDF1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	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. Thorsten Fröhlich (Introduction to AI in E-Commerce and Marketing)

Contributing Courses to Module

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

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

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

<table>
<tr><td colspan="2">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.</td></tr>
<tr><td>Links to other Modules within the Study Program

This module is similar to other modules in the field of Data Science & Artificial Intelligence</td><td>Links to other Study Programs of the University

All Master Programs in the IT & Technology field</td></tr>
</table>

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.
- 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 (4th ed.). ITGP.
- Laudon, K., & Traver, C. G. (2020). E-commerce: Business. Technology. Society. (16th ed.). Pearson.
- Martin, J., & Jurafsky, D. (2013). 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.
- Szeliski, R. (2022). Computer vision: Algorithms and applications (2nd ed.). Springer.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Ses-sions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

Corporate Governance of IT, Compliance, and Law

Module Code: DLMIGCR-01_E

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

Johannes Kent Walter (Corporate Governance of IT, Compliance, and Law)

Contributing Courses to Module

- Corporate Governance of IT, Compliance, and Law (DLMIGCR01-01_E)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- IT Governance: Motivation and Challenges
- COBIT Framework
- IT Compliance
- IT basic protection according to BSI IT law

Learning Outcomes	
Corporate Governance of IT, Compliance, and Law On successful completion, students will be able to ▪ explain the terms IT governance and IT compliance. ▪ categorize typical processes and activities from the area of IT governance and IT compliance. ▪ give an overview of the COBIT framework and its elements. ▪ give an overview of IT-Governance and explain its structure. ▪ reproduce important laws and regulations in the field of IT law and explain their areas of application.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Computer Science & Software Development	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Corporate Governance of IT, Compliance, and Law

Course Code: DLMIGCR01-01_E

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

Course Description

In this course, students learn terms and frameworks related to IT governance and IT compliance. First, a short introduction and an overview of the different aspects of IT governance and IT compliance are given; then, COBIT and IT basic protection are explained as two frameworks that are used in industrial practice. In addition, this course will introduce and discuss important legal frameworks and standards related to IT law.

Course Outcomes

On successful completion, students will be able to

- explain the terms IT governance and IT compliance.
- categorize typical processes and activities from the area of IT governance and IT compliance.
- give an overview of the COBIT framework and its elements.
- give an overview of IT-Governance and explain its structure.
- reproduce important laws and regulations in the field of IT law and explain their areas of application.

Contents

1. IT Governance: Motivation and Challenges
   - 1.1 Governance and IT Governance
   - 1.2 Frameworks for IT Governance
   - 1.3 Typical IT Governance, Service Management, and Security Frameworks and Standards
2. COBIT Framework
   - 2.1 Overview of the Elements of COBIT
   - 2.2 Governance and Management Objectives
   - 2.3 Use of COBIT and COBIT Design Factors
   - 2.4 The Target Cascade of COBIT
3. IT Compliance
   - 3.1 Introduction to IT Compliance
   - 3.2 Examples of National and International Guidelines: Risk Management Standards and Frameworks

3.3 IT Compliance: Typical Measures

4. Basic IT Protection According to BSI
   4.1 Overview and Structure
   4.2 Approach to IT Security Governance
   4.3 Usage Example of IT Security Governance

5. Introduction to IT Service Management
   5.1 What is Information Technology Service Management?
   5.2 What is ITIL® V4?
   5.3 What is ISO/IEC 20000-1:2018?
   5.4 Other ITSM Frameworks and Standards

6. IT Law
   6.1 Overview of Relevant Laws
   6.2 Protection of Intellectual Property
   6.3 IT Contracts
   6.4 Privacy

Literature
Compulsory Reading
Further Reading ▪ Cervone, H. F. (2017). Implementing IT governance: A primer for informaticians. Digital Library Perspectives, 33(4), 282—287.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

AI in Marketing and Analytics

Module Code: DLMAIEAPRS1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01	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. Thorsten Fröhlich (AI in Marketing and Analytics)

Contributing Courses to Module

- AI in Marketing and Analytics (DLMAIEAPRS01)

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

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

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

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 ed.). Cengage Learning.
- Butow, E., et al. (2020). Ultimate guide to social media marketing. Entrepreneur Press.
- Chandler, S. (2012). Own your niche. Authority Publishing.
- Chaters, B. (2011). Mastering search analytics. O'Reilley Publishing.
- Dib, A. (2018). The 1-page marketing plan. Page Two.
- Enge, E., Spencer, S., & Stricchiola, J. (2015). The art of SEO (3rd ed.). O'Reilly Media.
- Grigsby, M. (2018). Marketing analytics: A practical guide to improving consumer insights using data techniques (2nd ed.). London.
- Kerin, R., & Hartley, S. (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 myStudies

Study Format	**Course Type**
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Audio ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Personalization and Recommender Systems

Module Code: DLMAIEAPRS2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01	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. Thorsten Fröhlich (Personalization and Recommender Systems)

Contributing Courses to Module
▪ Personalization and Recommender Systems (DLMAIEAPRS02)

Module Exam Type	
Module Exam Study Format: myStudies Oral Assignment Study Format: Distance Learning Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents
▪ Foundation and Introduction ▪ Collaborative Filtering ▪ Content-Based Filtering ▪ Hybrid Recommender Systems ▪ Large-Scale Recommender Systems ▪ Perspectives
Learning Outcomes **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 field of Marketing & Sales	All Master Programs in the Marketing & Communication field

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 myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Demand Forecast and Inventory Control

Module Code: DLMAIEECMDF2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEECMDF01	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
Dr. Sheikh Radiah Rahim Rivu (Demand Forecast and Inventory Control)

Contributing Courses to Module
▪ Demand Forecast and Inventory Control (DLMAIEECMDF02)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam or Written Assessment: Case Study, 90 Minutes Study Format: myStudies Exam or Written Assessment: Case Study, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents	
▪ Newsvendor Model ▪ Traditional Methods of Demand Forecasting ▪ Data Driven methods of Demand Forecasting ▪ Inventory Models ▪ Further Effects	
Learning Outcomes **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 This module is similar to other modules in the field of Transportation & Logistics	**Links to other Study Programs of the University** All Master Programs in the Transport & Logistics field

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

1. Newsvendor Model
   - 1.1 Single Period Newsvendor (Classic, Cost Function)
   - 1.2 Demand as a Stochastic Quantity
   - 1.3 Demand Models
   - 1.4 Handling Censored Data

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
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- De Gooijer JG, Hyndman RJ (2006) 25 years of time series forecasting. Int J Forecast 22(3):443–473
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- Harris, F. (1990) How many parts to make at once. Operations Research, 38(6):947{950}.
- Hillier, F., Liebermann, G. (2020), ISE Introduction to Operations Research, McGraw-Hill
- 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
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- 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
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- 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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Case Study, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Practice Exam ☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Case Study, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	☑ Guideline
	☑ Slides	

Artificial Intelligence in Procurement

Module Code: DLMAIEADFP1

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

Dr. Anna Androvitsanea (Artificial Intelligence in Procurement)

Contributing Courses to Module

- Artificial Intelligence in Procurement (DLMAIEADFP01)

Module Exam Type

Module Exam	Split Exam
Study Format: myStudies Written Assessment: Project Report Study Format: Distance Learning Written Assessment: Project Report	

Weight of Module

see curriculum

Module Contents

In this course students will gain practical experience in modelling and building independently a running AI model or system to address a specific challenge in the field of procurement.

Learning Outcomes	
Artificial Intelligence in Procurement On successful completion, students will be able to ▪ analyze and understand real-world procurement problems. ▪ define an AI-based approach to address the chosen procurement topic. ▪ translate the learned AI theories and concepts into a running AI model or system to solve the chosen procurement challenge. ▪ explain the design choices made in the selection of the employed model or system and its implementation. ▪ critically evaluate the resulting AI model's or system's value for the chosen topic.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Transportation & Logistics	**Links to other Study Programs of the University** All Master Programs in the Transport & Logistics field

Artificial Intelligence in Procurement

Course Code: DLMAIEADFP01

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

Course Description

The focus of this course is to give students the opportunity to gain practical experience in the design and application of artificial intelligence technologies in the field of procurement. Together with their tutor, the students choose a specific challenge from a variety of procurement task in supply chain management, such as supplier selection, supplier communication, fraud detection or risk analysis. The goal is a prototypical implementation of a model or system of artificial intelligence in a suitable development environment to address the chosen procurement challenge. The choice of approach, the system or software implemented, and the resulting performance of the task must be reasoned out, explained, and documented

Course Outcomes

On successful completion, students will be able to

- analyze and understand real-world procurement problems.
- define an AI-based approach to address the chosen procurement topic.
- translate the learned AI theories and concepts into a running AI model or system to solve the chosen procurement challenge.
- explain the design choices made in the selection of the employed model or system and its implementation.
- critically evaluate the resulting AI model’s or system’s value for the chosen topic.

Contents

- In this course the students work on a practical implementation of an artificial intelligence use case of their choosing in the field of procurement. Students can also contribute their own project ideas related to the field of procurement. All relevant artifacts like use case evaluation, chosen implementation method, code, and outcomes are to be documented.

Literature
Compulsory Reading

Further Reading

- Cavalcante, I. M., Frazzon, E. M., Forcellini, F. A., Ivanov, D. (2019): A supervised machine learning approach to data-driven simulation of resilient supplier selection in digital manufacturing, International Journal of Information Management, vol. 49, p. 86-97, https://doi.org/10.1016/j.ijinfomgt.2019.03.004.
- Chopra A. AI in Supply & Procurement. 2019 Amity International Conference on Artificial Intelligence (AICAI), Artificial Intelligence (AICAI), 2019 Amity International Conference on. February 2019:308-316. doi:10.1109/AICAI.2019.8701357
- Krebs, K. D. (2020). How Can the Dod Adopt Commercial-Style Artificial Intelligence for Procurement? Artificial-Intelligence Capabilities, NPS-CM-20-152, https://dair.nps.edu/handle/123456789/4159
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- Mitchell Bronwyn, & Trebes Barry. (2018). 1. Procurement. In Managing Reality (3rd Edition) - Complete Set. ICE Publishing.
- Pierre Marquis, Odile Papini, & Henri Prade. (2020). A Guided Tour of Artificial Intelligence Research: Volume II: AI Algorithms. Springer.
- Sivakriskul, K. & Phienthrakul, T. (2021): Product Category Recommendation System Using Markov Model. In: Kaiser M.S., Xie J., Rathore V.S. (eds) Information and Communication Technology for Competitive Strategies (ICTCS 2020). Lecture Notes in Networks and Systems, vol 190. Springer, Singapore. https://doi-org.pxz.iubh.de:8443/10.1007/978-981-16-0882-7_60
- Torres Berru Y., López Batista V.F., Torres-Carrión P., Jimenez M.G. (2020): Artificial Intelligence Techniques to Detect and Prevent Corruption in Procurement: A Systematic Literature Review. In: Botto-Tobar M., Zambrano Vizuete M., Torres-Carrión P., Montes León S., Pizarro Vásquez G., Durakovic B. (eds) Applied Technologies. ICAT 2019. Communications in Computer and Information Science, vol 1194. Springer, Cham. https://doi-org.pxz.iubh.de:8443/10.1007/978-3-030-42520-3_21
- Zhou, R., Pang, J., Wang, Z., Lui, J. C. S., & Li, Z. (2021): A Truthful Procurement Auction for Incentivizing Heterogeneous Clients in Federated Learning. 2021 IEEE 41st International Conference on Distributed Computing Systems (ICDCS), Distributed Computing Systems (ICDCS), 2021 IEEE 41st International Conference on, ICDCS, 183–193. https://doi-org.pxz.iubh.de:8443/10.1109/ICDCS51616.2021.00026

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Concepts of Artificial Intelligence in Supply Chain Management

Module Code: DLMAIESCM1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	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. Claudia Heß (Concepts of Artificial Intelligence in Supply Chain Management)

Contributing Courses to Module
▪ Concepts of Artificial Intelligence in Supply Chain Management (DLMAIESCM01)

Module Exam Type	
Module Exam <u>Study Format: Distance Learning</u> Written Assessment: Case Study <u>Study Format: myStudies</u> Case Study	**Split Exam**
Weight of Module see curriculum	

Module Contents	
▪ 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	
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.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Data Science & Artificial Intelligence	**Links to other Study Programs of the University** 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

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Multi-Agent Systems

Module Code: DLMAIESCM2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	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. Silke Vaas (Multi-Agent Systems)

Contributing Courses to Module

- Multi-Agent Systems (DLMAIESCM02)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Written Assessment: Case Study	

Weight of Module

see curriculum

Module Contents

- 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	
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

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

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.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Robo Advisory

Module Code: DLMAIERAFT1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIESCM01, DLMAIEFT02	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
Dr. Anne Schwerk (Robo Advisory)

Contributing Courses to Module
▪ Robo Advisory (DLMAIERAFT01)

Module Exam Type	
Module Exam Study Format: Distance Learning Written Assessment: Written Assignment Study Format: myStudies Written Assessment: Written Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents	
▪ Introduction of Robo Advisory ▪ Types of Robo-Advisors and their Business Models ▪ Selected Areas of Application ▪ Principles of Goal-Based Investing ▪ Robo Economicus and Quantitative Models ▪ The Future Role of Robo-advisors and Asset Management Industry	
Learning Outcomes	
Robo Advisory On successful completion, students will be able to ▪ understand the history, drivers and importance of the Robo Advisors. ▪ recognize different types of Robo Advisors such as hybrid and pure models. ▪ identify the application of Robo Advisors in non-life insurance, chatbots, stocks and derivative pricing. ▪ describe principles of goal-based investing and risk tolerance frameworks. ▪ learn about quantitative approaches in Robo-advisory models. ▪ critically discuss the future role of Robo-advisors in the asset management industry. ▪ be familiar with the current regulatory landscape of Robo-advisory in Germany and beyond.	
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

Robo Advisory

Course Code: DLMAIERAFT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIESCM01, DLMAIEFT02

Course Description

Machines have been part of human life and no one can imagine a world without machines in every sphere of life. However, their application in the financial services industry in various forms such as Robo Advisors as asset managers has accelerated because of breathless digitalization. It is expected that assets under management by Robo Advisory companies will surpass USD 7 trillion by the end of 2025 as these companies offer better returns, low commission charges and sound risk tolerance strategies compared to incumbent financial institutions. Traditionally, financial advisors have been doing asset allocation which required significant investments in training human capabilities, therefore charging significant amounts of fees against their services. However, the increasing use of digital devices, sophistication in automation, AI and FinTechs has enabled various online platforms to do even more accurate asset allocations in a cost-effective manner. Robo advisors apply algorithms and are designed to minimize behavioral errors and are considered as a useful alternative to traditional investment ways. This course aims to provide students an in-depth understanding of the rise of Robo Advisory companies, different types, their core application areas by exploring various cases and examples. This course provides a discussion about principles of goal-based investing, quantitative models and risks tolerance framework of investors. This course also covers aspects related to the future of Robo Advisory, fraud detection capabilities and the current regulatory landscape in Germany and Europe.

Course Outcomes

On successful completion, students will be able to

- understand the history, drivers and importance of the Robo Advisors.
- recognize different types of Robo Advisors such as hybrid and pure models.
- identify the application of Robo Advisors in non-life insurance, chatbots, stocks and derivative pricing.
- describe principles of goal-based investing and risk tolerance frameworks.
- learn about quantitative approaches in Robo-advisory models.
- critically discuss the future role of Robo-advisors in the asset management industry.
- be familiar with the current regulatory landscape of Robo-advisory in Germany and beyond.

Contents

1. Introduction of Robo Advisory
    1.1 Definition of Robo advisors

1.2 Importance of Wealth and Asset Management Sector
1.3 Issues of Traditional Asset Management Sector
1.4 Drivers, History and Rise of Robo-advisory and Current State of Financial Markets

2. Types of Robo-Advisors and their Business Models
2.1 Machine Learning Types and Use in Finance
2.2 Hybrid/Bionic Robo Advisors
2.3 Pure Robo Advisors
2.4 Issues of Supervised vs. Unsupervised
2.5 Case studies such as Charles Schwab, Vanguard, Wealthfront and Betterment

3. Selected Areas of Application
3.1 Non-life Insurance
3.2 Chatbots
3.3 Stock and Derivative Price Predictions
3.4 Automatic Rebalancing of Portfolios
3.5 Tax-loss Harvesting

4. Principles of Goal-Based Investing
4.1 Investors Preferences
4.2 Goal-based Investing Process
4.3 Portfolio Modeling
4.4 Risk Tolerance Framework

5. Robo Economicus and Quantitative Models
5.1 Home Bias
5.2 Behavioral Accounting
5.3 Quantitative Approaches in Robo-Advisory Models
5.4 Risk Targets

6. The Future Role of Robo-advisors and Asset Management Industry
6.1 Future of Digital Advice
6.2 Machine Learning Models in Python
6.3 Frauds in Robo Advisory
6.4 The Regulatory Landscape of Robo-Advisory in Germany and Europe

Literature
Compulsory Reading
Further Reading ▪ Narang, R. (2009). Inside the black box: the simple truth about quantitative trading. John Wiley & Sons Ltd. ▪ Peter, S. (2021). Robo-Advisory: investing in the digital age. Palgrave Macmillan. ▪ Sironi, P. (2016). FinTech innovation: from Robo-advisors to goal based investing and gamification. John Wiley & Sons Ltd. ▪ Tatsat, H., Puri, S. and Lookbaugh, B. (2021). Machine learning and data science blueprints for finance: from building trading strategies to Robo-advisors using Python. Oreilly.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

NLP in Education

Module Code: DLMAIWNLPITE1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01	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

Dr. Anne Schwerk (NLP in Education)

Contributing Courses to Module

- NLP in Education (DLMAIWNLPITE01)

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

Weight of Module

see curriculum

Module Contents

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

<table>
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Learning Outcomes

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.

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Links to other Modules within the Study Program

This module is similar to other modules in the field of Data Science & Artificial Intelligence

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Links to other Study Programs of the University

All Master Programs in the IT & Technology field

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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, 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(4), 1–10. ▪ Jurafsky, D., & Martin, J. H. (2020). Speech and language processing (3rd ed.). Prentice Hall. ▪ Libbrecht, P., Declerck, T., Schlippe, T., Mandl, T., & Schiffner, D. (2020). NLP for student and teachers: Concept for an AI-based information literacy tutoring system. In Proceedings of the 29th ACM International Conference on Information and Knowledge Management (CIKM2020) (pp. 1–6). 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 myStudies

Study Format	Course Type
myStudies	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

NLP for Accessibility

Module Code: DLMAIWNLPITE2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIWNLPVA01	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

Dr. Anne Schwerk (NLP for Accessibility)

Contributing Courses to Module

- NLP for Accessibility (DLMAIWNLPITE02)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

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

Learning Outcomes	
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

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. ▪ 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.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

AI in Healthcare

Module Code: DLMAIEHCMI1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01	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
Dr. Anne Schwerk (AI in Healthcare)

Contributing Courses to Module
▪ AI in Healthcare (DLMAIEHCMI01)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam, 90 Minutes Study Format: myStudies Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

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

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.	
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 Devices)
2. Drug Discovery
   - 2.1 Target Identification & Virtual Screening
   - 2.2 Lead Optimization & ADME-Tox Prediction
   - 2.3 Clinical Trial Optimization
3. Personalized Care

Literature
Compulsory Reading

Further Reading

- Boccia, S., Abdulrazak, B., Aronson, S. J., Censi, F., De Moor, G. J. E., & Masic, I. (Eds.). (2020). Personalised Health Care. Springer.
- Bohr, A., & Memarzadeh, K. (Eds.). (2020). Artificial intelligence in healthcare. Academic Press.
- Brown, N. (2020). Artificial Intelligence in Drug Discovery. Royal Society of Chemistry.
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- IT Governance Privacy Team. (2020). EU General Data Protection Regulation (GDPR) – An implementation and compliance guide (4th ed.). ITGP.
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Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Practice Exam ☑ Online Tests

AI in Medical Imaging and Diagnostics

Module Code: DLMAIEHCMI2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01	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. Bertram Taetz (AI in Medical Imaging and Diagnostics)

Contributing Courses to Module
▪ AI in Medical Imaging and Diagnostics (DLMAIEHCMI02)

Module Exam Type	
Module Exam Study Format: Distance Learning Oral Assignment Study Format: myStudies Oral Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

- 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 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 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

Literature

Compulsory Reading

Further Reading

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- 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 .
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Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Audio ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Audio ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Medical NLP

Module Code: DLMAIEMNMR1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIIAC01, DLMAIEHCMI01	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. Kristina Schaaff (Medical NLP)

Contributing Courses to Module

- Medical NLP (DLMAIEMNMR01)

Module Exam Type	
Module Exam Study Format: Distance Learning Written Assessment: Written Assignment	**Split Exam**
Weight of Module see curriculum	

Module Contents

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

Learning Outcomes	
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

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 Fundamentals of Neural Networks
   - 3.2 Recurrent Neural Network based Approaches
   - 3.3 Transformer based Approaches

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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Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Medical Robotics and Devices

Module Code: DLMAIEMNMR2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01 and (DLMDSML01 or DLMDSDL01 or DLMAIAI01 or 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. Esther Stenau (Medical Robotics and Devices)

Contributing Courses to Module
▪ Medical Robotics and Devices (DLMAIEMNMR02)

Module Exam Type	
Module Exam Study Format: Distance Learning Written Assessment: Case Study Study Format: myStudies Written Assessment: Case Study	**Split Exam**
Weight of Module see curriculum	

Module Contents	
▪ Internet of Medical Things ▪ Wearable and Implantable Devices ▪ Fundamentals of Robotics ▪ Navigation and Registration ▪ Treatment Planning ▪ Design of Medical Robots	
Learning Outcomes **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 This module is similar to other modules in the field of Engineering	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Medical Robotics and Devices

Course Code: DLMAIEMNMR02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01 and (DLMDSML01 or DLMDSDL01 or DLMAIAI01 or DLMDSPWP01)

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 Introduction to IoMT
   - 1.2 Medical Robots
   - 1.3 Data-Driven Medicine
   - 1.4 Image Management
   - 1.5 Cybersecurity
   - 1.6 Current Legislation and Trends

2. Wearable and Implantable Medical Devices

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Ses-sions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

High-Level Vision

Module Code: DLMAIWCCV1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01	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. Konstantinos Amplianitis (High-Level Vision)

Contributing Courses to Module

- High-Level Vision (DLMAIWCCV01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Classification
- Recognition
- Image Synthesis
- Computer Vision and NLP
- Current Challenges

Learning Outcomes	
High-Level Vision On successful completion, students will be able to ▪ understand current approaches to image classification and retrieval. ▪ summarize goals and methods of scene understanding. ▪ disambiguate different tasks in object recognition, semantic and instance segmentation. ▪ explain solutions to common problems in image enhancement. ▪ understand the connection of Computer Vision to other forms of cognitive computing like NLP. ▪ 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

High-Level Vision

Course Code: DLMAIWCCV01

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

Course Description

Computer vision is generally understood as a subfield of artificial intelligence and primarily concerned with developing and researching methods that enable computers to gain a high-level understanding of images or videos. This allows computers to perform high level visual cognitive tasks, emulating or even surpassing the human capability to derive information from visual input.In this course, a thorough introduction to the higher-level cognitive aspects of Computer Vision like classification, recognition, and semantic segmentation is given and touch-points to the field of Natural Language Processing are illuminated. 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

- understand current approaches to image classification and retrieval.
- summarize goals and methods of scene understanding.
- disambiguate different tasks in object recognition, semantic and instance segmentation.
- explain solutions to common problems in image enhancement.
- understand the connection of Computer Vision to other forms of cognitive computing like NLP.
- appreciate current challenges in Computer Vision with respect to model training, fairness, and robustness.

Contents

1. Classification
   - 1.1 Image Classification
   - 1.2 Content-based image retrieval
   - 1.3 Scene Understanding

2. Recognition
   - 2.1 Object Recognition
   - 2.2 Semantic and Instance Segmentation
   - 2.3 Face Recognition

3. Image Synthesis
   3.1 Image Synthesis and Image Enhancement
   3.2 Image Extrapolation
   3.3 Artistic Style Transfer

4. Computer Vision and NLP
   4.1 Scene Description
   4.2 Visual Question Answering
   4.3 Synthesizing Images from Descriptions

5. Current Challenges
   5.1 Current Challenges in Computer Vision Applications
   5.2 Data Privacy in Computer Vision Applications

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.
- Klette, R. (2014). Concise Computer Vision: An Introduction into Theory and Algorithms. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Project: Computer Vision

Module Code: DLMAIWCCV2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIWFCV01, DLMAIWFCV02, DLMAIWCCV01	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. Konstantinos Amplianitis (Project: Computer Vision)

Contributing Courses to Module

- Project: Computer Vision (DLMAIWCCV02)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Written Assessment: Project Report Study Format: myStudies Written Assessment: Project Report	

Weight of Module

see curriculum

Module Contents

In this course, the students will work on a practical Computer Vision use-case based on a number of choices in the task description.

Learning Outcomes	
Project: Computer Vision On successful completion, students will be able to ▪ formulate and implement a Computer Vision use case. ▪ transfer knowledge of Computer Vision methodology to a real-world use-case. ▪ synthesize a solution to a complex Computer Vision task from known building blocks. ▪ analyze the suitability of alternative approaches with respect to the project task. ▪ critically reason about pertinent design choices. ▪ make apposite architectural conceptions.	
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

Project: Computer Vision

Course Code: DLMAIWCCV02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSML01, DLMDSDL01, DLMAIRIL01, DLMAIWFCV01, DLMAIWFCV02, DLMAIWCCV01

Course Description

Computer vision is generally understood as a subfield of artificial intelligence and primarily concerned with developing and researching methods that enable computers to gain a high-level understanding of images or videos. This allows computers to perform high level visual cognitive tasks, emulating or even surpassing the human capability to derive information from visual input.In this course, the students will work on a practical Computer Vision use-case based on a number of choices in the task description. The choice of approach, the system or software implemented, and the resulting performance on the task are to be reasoned about, explained, and documented. To this end, students make practical use of the methodological knowledge acquired in previous courses by applying them to relevant real-world problems.

Course Outcomes

On successful completion, students will be able to

- formulate and implement a Computer Vision use case.
- transfer knowledge of Computer Vision methodology to a real-world use-case.
- synthesize a solution to a complex Computer Vision task from known building blocks.
- analyze the suitability of alternative approaches with respect to the project task.
- critically reason about pertinent design choices.
- make apposite architectural conceptions.

Contents

- This course aims at the practical implementation of a Computer Vision project. Students can choose from a list of project topics as detailed in the task description.

Literature

Compulsory Reading

Further Reading

- Dadhich, A. (2018). Practical computer vision. Pakt Publishing.
- Hornberg, A. (2017). Handbook of machine and computer vision (2nd ed.). Wiley-VCH.
- Shanmugamani, R. (2018). Deep learning for computer vision. Pakt Publishing.
- Solem, J. E. (2012). Programming computer vision with Python. O'Reilly.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Industrial and Mobile Robots

Module Code: DLMAIEAR1

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. Leonardo Riccardi (Industrial and Mobile Robots)

Contributing Courses to Module

- Industrial and Mobile Robots (DLMAIEAR01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Architectural Components of Mobile and Industrial Robots
- Mathematical Description
- Design of Interactions and Control

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.	
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)

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Slides	**Exam Preparation** ☑ Practice Exam ☑ Online Tests

Project: Collaborative Robotics

Module Code: DLMAIEAR2

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

Jacko Nudzor (Project: Collaborative Robotics)

Contributing Courses to Module

- Project: Collaborative Robotics (DLMAIEAR02)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Written Assessment: Project Report Study Format: myStudies Written Assessment: Project Report	

Weight of Module

see curriculum

Module Contents

- Human-robot interaction
- Safety operation
- Human-friendly robot design
- A current list of topics is located in the Learning Management System.

Learning Outcomes	
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

Project: Collaborative Robotics

Course Code: DLMAIEAR02

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

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. Springer.
- Corke, P. (2017). Robotics, vision and control (2nd ed.). Springer.
- Mihelj, M., Bajd, T., Ude, A., Lenarčič, J., Stanovnik, A., Munih, M., ... Šlajpah, S. (2019). Robotics (2nd ed.). Springer.
- Siciliano, B., & Khatib, O. (Eds.). (2016). Springer handbook of robotics (2nd ed.). 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). Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Project Report

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Architectures of Self-Driving Vehicles

Module Code: DLMDSEAAD1

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

Dr. Jan Hüls (Architectures of Self-Driving Vehicles)

Contributing Courses to Module

- Architectures of Self-Driving Vehicles (DLMDSEAAD01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Architectural Patterns of a Self-Driving Car
- Perception and Motion Control
- Social Impact of Autonomous Vehicles

<table>
<tr><td colspan="2">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.</td></tr>
<tr><td>Links to other Modules within the Study Program

This module is similar to other modules in the field of Engineering</td><td>Links to other Study Programs of the University

All Master Programs in the IT & Technology field</td></tr>
</table>

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload

Self Study	Contact Hours	Tutorial/Tutorial Support	Self Test	Independent Study	Hours Total
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods

Tutorial Support	Learning Material	Exam Preparation
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Practice Exam ☑ Online Tests

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Review Book
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Case Study: Localization, Motion Planning and Sensor Fusion

Module Code: DLMDSEAAD2

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

Dr. Jan Hüls (Case Study: Localization, Motion Planning and Sensor Fusion)

Contributing Courses to Module

- Case Study: Localization, Motion Planning and Sensor Fusion (DLMDSEAAD02)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Algorithms for Localization and Navigation
- Sensor Fusion Methods for Localization and Objects Tracking
- Motion Planning Algorithms

Learning Outcomes	
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 Programs in the IT & Technology field

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

1. Motion and Odometry
   - 1.1 Basic principles
   - 1.2 Motion models
   - 1.3 Navigation by odometry
   - 1.4 Holonomic and non-holonomic motion

1.5 Errors

2. Local Navigation
    2.1 Basic concepts
    2.2 Path finding
    2.3 Obstacle avoidance

3. Localization
    3.1 Basic concepts
    3.2 Triangulation
    3.3 GPS
    3.4 Probabilistic localization
    3.5 Uncertainty of motion

4. Sensor Fusion
    4.1 Sensors
    4.2 Elaborating data from sensors
    4.3 Kalman filter
    4.4 Extended Kalman filter
    4.5 Tracking objects

5. Motion Planning
    5.1 Path planning
    5.2 Motion prediction
    5.3 Trajectory generation

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	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Functional Security

Module Code: DLMAIEFSCVAS1

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. Petra Beenken (Functional Security)

Contributing Courses to Module

- Functional Security (DLMAIEFSCVAS01)

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

- Standards for Functional Security
- Approaches for Design for Functional Security and Safety
- Attacks and Defenses

Learning Outcomes	
Functional Security On successful completion, students will be able to ▪ understand the main issues related to safety and security. ▪ name diverse standards of safety and security. ▪ understand standards used in automotive. ▪ name diverse IT standards. ▪ apply common approaches to enforce security and safety. ▪ understand and prevent possible cyber and physical attacks.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Computer Science & Software Development	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Functional Security

Course Code: DLMAIEFSCVAS01

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

Course Description

Functional security and safety must be considered when designing software as well as hardware for several applications, in particular for automotive. This course illustrates the main standards of functional security and functional safety, as well as approaches for enforcing them in design.

Course Outcomes

On successful completion, students will be able to

- understand the main issues related to safety and security.
- name diverse standards of safety and security.
- understand standards used in automotive.
- name diverse IT standards.
- apply common approaches to enforce security and safety.
- understand and prevent possible cyber and physical attacks.

Contents

1. Introduction
   - 1.1 Functional Security
   - 1.2 Automotive Safety
   - 1.3 Relevant Standards (ISO 26262, IEC 61508, ISO 27001, EU directive 2001/95/EG, ISO 25119)
2. Functional Safety Standard ISO 26262
   - 2.1 Introduction
   - 2.2 Automotive Safe Integrity Levels (ASIL)
   - 2.3 Recommended Techniques
3. IT Security Standards
   - 3.1 ISO 27001
   - 3.2 ISO 15408
   - 3.3 ISO 21434
   - 3.4 SAE J3061
   - 3.5 AECQ

4. Approaches
   - 4.1 Safe Failure Fraction (SFF)
   - 4.2 Diagnostic Coverage (DC)
   - 4.3 Hazard Analysis and Risk Assessment (HARA)
   - 4.4 Fault Tree Analysis (FTA)
   - 4.5 Failure Modes, Effects & (Diagnostic, Criticality) Analysis (FME[C,D]A)

5. Attacks and Defenses
   - 5.1 Cyber Attacks
   - 5.2 Physical Attacks
   - 5.3 MISRA C/C++ Guidelines

Literature

Compulsory Reading

Further Reading

- Smith D.J., Simpson K. (2016). The Safety Critical Systems Handbook. (4th ed.) Elsevier.
- Smith D.j. (2017). Reliability, Maintainability and Risk (9th ed.) Elsevier.
- Rausand, M. (2014). Reliability of Safety-Critical Systems: Theory and Applications Wiley.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Computer Vision for Autonomous Systems

Module Code: DLMAIEFSCVAS2

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. Konstantinos Amplianitis (Computer Vision for Autonomous Systems)

Contributing Courses to Module

- Computer Vision for Autonomous Systems (DLMAIEFSCVAS02)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

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

<table>
<tr><td colspan="2">Learning Outcomes

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.</td></tr>
<tr><td>Links to other Modules within the Study Program

This module is similar to other modules in the field of Engineering</td><td>Links to other Study Programs of the University

All Master Programs in the IT & Technology field</td></tr>
</table>

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 and 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 and Night Vision
   - 2.2 Lidar
   - 2.3 Radar
   - 2.4 Ultrasound

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.
- Distante, A., & Distante, C. (2020). Handbook of image processing and computer vision: Volume 1: From energy to image. Springer International Publishing. https://doi.org/10.1007/978-3-030-38148-6
- Gonzalez, R. C., & Woods, R. E. (2017). Digital Image Processing (4th ed.). Pearson.
- Peters, J. F. (2017). Foundations of Computer Vision (Vol. 124). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-319-52483-2
- Szelinski, R. (2020). Computer Vision: Algorithms and Applications. (2nd ed.). Springer Nature.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Written Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Industrial Automation

Module Code: DLMDSINDA

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	Minimaldauer: 1 Semester	WiSe/SoSe	English

Module Coordinator
Dr. Sahar Qaadan (Industrial Automation)

Contributing Courses to Module
▪ Industrial Automation (DLMDSINDA01)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam, 90 Minutes Study Format: myStudies Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- 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	
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

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

Literature

Compulsory Reading

Further Reading

- Cassandras, C. G., & Lafortune, S. (2021). Introduction to discrete event systems. Springer.
- Hooley, G., Nicoulaud, B., Rudd, J. M., & Piercy, N. (2020). Marketing strategy and competitive positioning. (7th ed.). Pearson.
- Kaplan, R. and McMillan, D. (2021), . Harvard Business Review Digital Articles.
- Linz, P. (2017). An introduction to formal languages and automata. (6th ed.). Jones & Bartlett Learning.
- Reisig, W. (2013). Understanding Petri nets: Modeling techniques, analysis methods, case studies. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Practice Exam ☑ Online Tests

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Slides	

Advanced NLP and Computer Vision

Module Code: DLMAIANLPCV

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSPWP01, DLMDSML01, DLMAINLPCV01	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 (Advanced NLP and Computer Vision)

Contributing Courses to Module
▪ Advanced NLP and Computer Vision (DLMAIEAIS01)

Module Exam Type	
Module Exam Study Format: myStudies Exam or Written Assessment: Written Assignment, 90 Minutes Study Format: Distance Learning Exam or Written Assessment: Written Assignment, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents	
- Machine Translation and Semantic Text Interpretation - Recovery of Scene Geometry - Semantic Image and Video Analysis - Object Tracking	
Learning Outcomes **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 field of Data Science & Artificial Intelligence	All Master Programs in the IT & Technology field

Advanced NLP and Computer Vision

Course Code: DLMAIEAIS01

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

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Written Assignment, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	☑ Guideline
	☑ Slides	

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam or Written Assessment: Written Assignment, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
100 h	0 h	25 h	25 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	☑ Guideline
	☑ Slides	

Project: NLP and Computer Vision

Module Code: DLMAIEAIS2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DDLMDSAM, DLMDSPWP, DLMDSML, DLMAINLPCV, DLMAIEAIS01	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: NLP and Computer Vision)

Contributing Courses to Module

- Project: NLP and Computer Vision (DLMAIEAIS02)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Portfolio	

Weight of Module

see curriculum

Module Contents

- Transfer and application of methodological computer vision and NLP knowledge
- Implementation of an NLP or computer vision software module

Learning Outcomes	
Project: NLP and Computer Vision On successful completion, students will be able to ▪ apply knowledge of NLP and computer vision methods to practical problems. ▪ evaluate different methods, algorithms, and approaches to solving a given problem with respect to its set of constraints. ▪ recognize the benefits and drawbacks of design options and choices. ▪ build real-world computer vision or NLP applications.	
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

Project: NLP and Computer Vision

Course Code: DLMAIEAIS02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DDLMDSAM, DLMDSPWP, DLMDSML, DLMAINLPCV, DLMAIEAIS01

Course Description

This course is intended to give students an opportunity to apply their knowledge in NLP and computer vision to a real-world implementation task. To this end, an apposite solution for a given task and the accompanying set of constraints must be found. Methodological and algorithmic choices must be appropriately evaluated to find the best path forward. The found solution design is implemented as a running piece of software, furthering the students' programming skills.

Course Outcomes

On successful completion, students will be able to

- apply knowledge of NLP and computer vision methods to practical problems.
- evaluate different methods, algorithms, and approaches to solving a given problem with respect to its set of constraints.
- recognize the benefits and drawbacks of design options and choices.
- build real-world computer vision or NLP applications.

Contents

- In this course, students will put the knowledge acquired in the preceding course, Advanced NLP and Computer Vision, into practice through the implementation of an NLP or computer vision project of their choosing.

Literature
Compulsory Reading
Further Reading ▪ Bengfort, B., & 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). 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. John Wiley & Sons Ltd. ▪ Jurafsky, D., & Martin, J. H. (2008). Speech and language processing. Prentice Hall. Szeliski, R. (2011). Computer vision: Algorithms and applications (2nd ed.). Springer VS.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

Data Engineering

Module Code: DLMDSEDE1

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

Georgi Dimchev (Data Engineering)

Contributing Courses to Module

- Data Engineering (DLMDSEDE01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Principles of Data Engineering
- Paradigms for Data Processing at Scale
- Overview on Data Governance, Security, and Protection
- Common Cloud Platforms
- DataOps Approach

Learning Outcomes	
Data Engineering On successful completion, students will be able to ▪ understand the foundational concepts in data engineering. ▪ categorize important data-processing classes. ▪ summarize common approaches to data governance and security and contribute to the broader societal discussion on an academic level. ▪ compare different common public cloud offerings. ▪ recognize current approaches to data operations (DataOps) including productivity tools to facilitate working in interdisciplinary teams.	
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

Data Engineering

Course Code: DLMDSEDE01

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

Course Description

The focus of this first course in the Data Engineering elective module is to introduce students to important principles, concepts, methods and approaches in this subject domain. In order to achieve this goal, the course moves from an exposition of the foundational principles of data engineering to a thorough treatment of the core data processing classes. Modern architectural paradigms such as Microservices are explained, and important factors in data governance and protection are addressed. In this context, students are enabled to reflect on modern data protection principles and their societal implications and implement these principles into large-scale data-intensive systems. Aspects of cloud computing are introduced via an overview of the most common offerings on the market. Finally, a state-of-the-art agile perspective on the operation of data pipelines is given by an exposition to the emerging notion of DataOps and the productivity tools around it to facilitate working in interdisciplinary teams.

Course Outcomes

On successful completion, students will be able to

- understand the foundational concepts in data engineering.
- categorize important data-processing classes.
- summarize common approaches to data governance and security and contribute to the broader societal discussion on an academic level.
- compare different common public cloud offerings.
- recognize current approaches to data operations (DataOps) including productivity tools to facilitate working in interdisciplinary teams.

Contents

1. Foundations of Data Systems
   - 1.1 Reliability
   - 1.2 Scalability
   - 1.3 Maintainability

2. Data Processing at Scale
   - 2.1 Batch Processing
   - 2.2 Stream and Complex Event Processing

Literature

Compulsory Reading

Further Reading

- Andrade, H., Gedik, B., & Turaga, D. (2014). Fundamentals of stream processing: Application design, systems, and analytics. Cambridge University Press.
- Axelrod, C. W. (2013). Engineering safe and secure software systems. Artech House.
- Kleppmann, M. (2017). Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. O‘Reilly.
- Newman, S. (2015). Building microservices: Designing fine-grained systems. O'Reilly.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video	☑ Online Tests ☑ Guideline

Project: Data Engineering

Module Code: DLMDSEDE2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSEDE01	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. Max Pumperla (Project: Data Engineering)

Contributing Courses to Module

- Project: Data Engineering (DLMDSEDE02)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Knowledge transfer and application to practical problems
- Implementation of a data infrastructure building block

Learning Outcomes	
Project: Data Engineering On successful completion, students will be able to ▪ apply the principles of data engineering to a practical application. ▪ analyze data engineering approaches with respect to a given project task. ▪ reason about the benefits and drawbacks of solution alternatives for a given implementation task. ▪ make apposite architectural choices. ▪ implement aspects of a modern data pipeline abiding by strict data protection principles.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Data Science & Artificial Intelligence	**Links to other Study Programs of the University** All Master Programs in the IT & Technology field

Project: Data Engineering

Course Code: DLMDSEDE02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSEDE01

Course Description

The second course of the Data Engineering elective module builds upon theoretical and methodological insights from the first course. It provides opportunities for students to put their newly-acquired knowledge into practical application by completing a data engineering project.In order to find an appropriate and viable approach, students will have to reason about and evaluate the benefits and drawbacks of possible architectural choices. Once an informed decision has been met, the chosen approach is implemented as a running piece of data infrastructure.

Course Outcomes

On successful completion, students will be able to

- apply the principles of data engineering to a practical application.
- analyze data engineering approaches with respect to a given project task.
- reason about the benefits and drawbacks of solution alternatives for a given implementation task.
- make apposite architectural choices.
- implement aspects of a modern data pipeline abiding by strict data protection principles.

Contents

- The second course of the Data Engineering elective revolves around the implementation of a data engineering project chosen from a set of project suggestions. Students can also contribute their own project ideas.

Literature
Compulsory Reading
Further Reading ▪ Farcic, V. (2016). The DevOps 2.0 toolkit: Automating the continuous deployment pipeline with containerized microservices. CreateSpace Independent Publishing Platform. ▪ Karau, H., Konwinski, A., Wendell, P., & Zaharia, M. (2015). Learning Spark: Lightning fast data analysis. O'Reilly Media. ▪ Kleppmann, M. (2017). Designing data intensive applications: The big ideas behind reliable, scalable, and maintainable systems. O'Reilly Media. ▪ Narkhede, N., Shapira, G., & Palino, T. (2017). Kafka: The definitive guide: Real-time data and stream processing at scale. O'Reilly Media. ▪ White, T. (2015). Hadoop: The definitive guide: Storage and analysis at Internet scale (4th ed.). O'Reilly Media.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format myStudies

Study Format myStudies	**Course Type**

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

IT Project Management

Module Code: DLMCSITPM

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. Carsten Skerra (IT Project Management)

Contributing Courses to Module
▪ IT Project Management (DLMBITPAM01)

Module Exam Type	
Module Exam Study Format: myStudies Exam, 90 Minutes Study Format: Distance Learning Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Organizing the work
- Cost estimation and controlling
- The human factor
- Organizing small and medium projects
- Organizing large projects

Learning Outcomes	
IT Project Management On successful completion, students will be able to ▪ critically reflect the status of knowledge on IT project management. ▪ set up different IT project management formats (small, medium and large projects) and know the methods for managing these different IT projects professionally. ▪ develop an IT management proposal as the fundament of a professional IT project management concept. ▪ understand and integrate different IT management project plans (e.g., time plan, cost plan, resources plan, risk plan) and use those plans in an integrative IT project planning and controlling scheme. ▪ organize and to lead an IT project team and its core and/or extended team members.	
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 Computer Science & Software Development	All Master Programmes in the IT & Technology field

IT Project Management

Course Code: DLMBITPAM01

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

Course Description

The purpose of this course is to introduce students to the concepts involved in IT project management. This is achieved through the development of an understanding of the fundamental tenets of project management enhancing the students' ability to apply their knowledge, skills and competencies in analyzing and solving IT project management problems. A special focus is put on the specifics of IT project organization, cost management and the human factor within IT projects.

Course Outcomes

On successful completion, students will be able to

- critically reflect the status of knowledge on IT project management.
- set up different IT project management formats (small, medium and large projects) and know the methods for managing these different IT projects professionally.
- develop an IT management proposal as the fundament of a professional IT project management concept.
- understand and integrate different IT management project plans (e.g., time plan, cost plan, resources plan, risk plan) and use those plans in an integrative IT project planning and controlling scheme.
- organize and to lead an IT project team and its core and/or extended team members.

Contents

1. Introduction: Characteristics of IT Projects
   - 1.1 Defining IT Projects
   - 1.2 Overview on Typical Roles and Phases of IT Projects
   - 1.3 Risks and Challenges of IT Projects
   - 1.4 Role of an IT Project Manager

2. Organizing the Work
   - 2.1 Project Breakdown Structure, Work Packages
   - 2.2 Prioritization
   - 2.3 Time Planning, Milestones, Gantt Charts
   - 2.4 Definition of Done

3. Cost Estimation and Controlling

3.1 Challenges of Cost Estimation in IT Projects
3.2 Estimation Techniques: 3-Point Estimation, Double Blind Expert Estimation, Function Points
3.3 Cost Controlling Using Earned Value Analysis
3.4 Risk Management

4. The Human Factor
4.1 Vision Keeping
4.2 Stakeholder Management
4.3 Conflict Management

5. Organizing Small and Medium Projects
5.1 Rational Unified Process (RUP)
5.2 Agile Software Processes
5.3 Scrum
5.4 Plan-driven Project Management in Small Projects

6. Organizing Large Projects
6.1 PMBOK Guide
6.2 Prince2
6.3 Multi Project Management
6.4 Agile Software Processes in Large Projects
6.5 Selection of the Appropriate Project Management Method

Literature

Compulsory Reading

Further Reading

- Stephens, R. (2015). Beginning software engineering. Wrox, a Wiley Brand.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Practice Exam ☑ Online Tests

Project: Technical Project Planning

Module Code: DLMDSETPL1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMBITPAM01	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. Dorian Mora (Project: Technical Project Planning)

Contributing Courses to Module

- Project: Technical Project Planning (DLMDSETPL01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

In this course, students learn to apply the project management concepts they learned in previous modules in a real-world project.

Learning Outcomes	
Project: Technical Project Planning On successful completion, students will be able to ▪ apply the concepts of project management to real-world tasks and problems. ▪ translate the learned theories into the practice of project management. ▪ analyze a real-world problem and define and implement a project to resolve it. ▪ appraise the results of a project performed and identify what worked well and what did not. ▪ explain the work they perform, give its scientific background, and produce adequate documentation.	
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

Project: Technical Project Planning

Course Code: DLMDSETPL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMBITPAM01

Course Description

The focus of this course is to apply the project management knowledge gained previously in a practical portfolio project and reflect on the results. Students engage in this portfolio project and document the results, reflecting on the project management concepts they apply and the influence of these concepts on the success of the project.

Course Outcomes

On successful completion, students will be able to

- apply the concepts of project management to real-world tasks and problems.
- translate the learned theories into the practice of project management.
- analyze a real-world problem and define and implement a project to resolve it.
- appraise the results of a project performed and identify what worked well and what did not.
- explain the work they perform, give its scientific background, and produce adequate documentation.

Contents

- In this course, students perform and document a portfolio project in which they apply the project management topics covered in previous modules.

Literature

Compulsory Reading

Further Reading

- Hinde, D. (2012). PRINCE2 Study Guide. John Wiley & Sons.
- Kneuper, R. (2018). Software processes and lifecycle models. Springer Nature Switzerland.
- Phillips, J. (2010). IT project management: On track from start to finish (3rd ed.). McGraw-Hill.
- Project Management Institute. (2013). A guide to the project management body of knowledge: PMBOK guide.
- Schwaber, K. (2004). Agile project management with Scrum. Microsoft Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

User Interface and Experience

Module Code: DLMAIEUIUX1

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. Adelka Niels (User Interface and Experience)

Contributing Courses to Module

- User Interface and Experience (DLMAIEUIUX01)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam, 90 Minutes Study Format: myStudies Exam, 90 Minutes	**Split Exam**
Weight of Module see curriculum	

Module Contents

- ROI of UX design
- Role and mindset of UX design in IT projects
- The UX design process
- UX psychology: How the human mind works
- User research
- UX design basics

<table>
<tr><td colspan="2">Learning Outcomes
User Interface and Experience
On successful completion, students will be able to
Understand what design is about and the crucial aspects of good design
understand and define the role of the UI/UX designer within a project.
explain the UX design process and the user-centered mindset.
advocate the importance of UX design for IT projects.
describe the basic methods of user research, user testing, and user-centered design.</td></tr>
<tr><td>Links to other Modules within the Study Program
This module is similar to other modules in the field of Data Science & Artificial Intelligence</td><td>Links to other Study Programs of the University
All Master Programmes in the IT & Technology field</td></tr>
</table>

User Interface and Experience

Course Code: DLMAIEUIUX01

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

Course Description

UX design is crucial to the development of new IT services and applications and enhances the quality of the outcome. Applying UX design techniques can significantly and positively change the software development process, and good UX design is the result of effective teamwork. Within this course the students will understand the mindset, basic techniques, and impact of UX design on IT projects. They will learn how the UX design process works and the role of the UX designer within IT projects. They will also gain skills in the type of collaboration that produces the best results. Using their basic knowledge about good design, the students will know when it is appropriate that they make small changes to UIs themselves and when it is time to consult a designer.

Course Outcomes

On successful completion, students will be able to

- Understand what design is about and the crucial aspects of good design
- understand and define the role of the UI/UX designer within a project.
- explain the UX design process and the user-centered mindset.
- advocate the importance of UX design for IT projects.
- describe the basic methods of user research, user testing, and user-centered design.

Contents

1. ROI of UX design
   - 1.1 Efficacy
   - 1.2 Efficiency
   - 1.3 The impact of design on use errors

2. Role and Mindset of UX design in IT projects
   - 2.1 The role of UX design: the UX designer
   - 2.2 The UX mindset: putting the user first

3. The UX design Process
   - 3.1 In a waterfall process environment
   - 3.2 In an agile process environment

4. UX Psychology: How the Human Mind Works

4.1 Perceptual psychology
4.2 Information processing
4.3 Decision-making
4.4 Situation awareness
4.5 Errors

5. User Research
5.1 The benefit of user research
5.2 Basic research techniques
5.3 User testing

6. UX design Basics
6.1 Interaction design
6.2 Information architecture
6.3 Screen design
6.4 Graphic design
6.5 Rules of good design

Literature

Compulsory Reading

Further Reading

- Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). About face: The essentials of interaction design (5th ed.). Wiley.
- Johnson, J. (2010). Designing with the mind in mind. Elsevier.
- Preece, J., Sharp, H., & Rogers, Y. (2015). Interaction design: Beyond human-computer interaction (5th ed.). Wiley.
- Unger, R., & Chandler, C. (2012). A project guide to UX design: For user experience designers in the field or in the making. New Riders Pub.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	**Course Type**
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video	☑ Practice Exam ☑ Online Tests

Project: Human Computer Interaction

Module Code: DLMAIEUIUX2

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMAIEUIUX01	MA	5	150 h

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

Module Coordinator

Prof. Dr. Adelka Niels (Project: Human Computer Interaction)

Contributing Courses to Module

- Project: Human Computer Interaction (DLMAIEUIUX02)

Module Exam Type	
Module Exam Study Format: myStudies Portfolio Study Format: Distance Learning Portfolio	**Split Exam**
Weight of Module see curriculum	

Module Contents

In this course the students will gain practical experience in user experience design. They will conduct user testing for a given user interface and work on developing improvements. The work process and the results will become part of a portfolio.

Learning Outcomes	
Project: Human Computer Interaction On successful completion, students will be able to ▪ evaluate the usability of a user interface. ▪ conduct user testing. ▪ understand the practical implications of putting users first. ▪ make small changes in existing user interfaces and recognize the situations in which a user experience designer should be consulted.	
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

Project: Human Computer Interaction

Course Code: DLMAIEUIUX02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMAIEUIUX01

Course Description
In this course the students will gain practical experience in user experience design. They will set up and conduct a user testing for a given user interface and develop improvements. The work process and the results will become part of a portfolio.

Course Outcomes

On successful completion, students will be able to

- evaluate the usability of a user interface.
- conduct user testing.
- understand the practical implications of putting users first.
- make small changes in existing user interfaces and recognize the situations in which a user experience designer should be consulted.

Contents

- User experience design focusses on the needs of users. Within this portfolio project the students put into practice basic techniques which lead to good user-centered design. They learn how to test the user experience and usability of an application by conducting user tests, and they also learn how to develop and test ideas for improvement. Students will finish this course having gained practical experience working within the mindset of putting users first.

Literature
Compulsory Reading
Further Reading ▪ Barnum, C. (2010). Usability testing essentials: Ready, set...test! Morgan Kaufmann. ▪ Cooper, A., Reimann, R., Cronin, D., & Noessel, C. (2014). About face: The essentials of interaction design. Wiley. ▪ Johnson, J. (2010). Designing with the mind in mind. Elsevier. ▪ Microsoft Windows Dev Center. (2018). Guidelines. Retrieved from https://docs.microsoft.com/en-us/windows/desktop/uxguide/guidelines ▪ Preece, J., Sharp, H., & Rogers, Y. (2015). Interaction design: Beyond human-computer interaction. Wiley. ▪ Unger, R., & Chandler, C. (2012). A project guide to UX design. New Riders.

Study Format myStudies

Study Format	Course Type
myStudies	

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

International IT Law

Module Code: DLMIMWITR1_E

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

Dr. Mohammad Shackow (International IT Law)

Contributing Courses to Module

- International IT Law (DLMIMWITR01_E)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Introduction
- E-Business and E-Commerce
- Intellectual Property
- Privacy and Data Protection
- Information Security and Computer Crime
- Online Media and Telecommunication

<table>
<tr><td colspan="2">Learning Outcomes
International IT Law
On successful completion, students will be able to
identify and explain the differences between national, transnational and international legal systems.
identify interfaces between general legal concepts and IT-relevant law.
identify legal requirements for IT contracting and assess their impact on the (electronic) commercialization of IT products or services.
assess the impact of the European Data Protection Regulation on business processes and make recommendations for implementation.
identify the legal views of selected transnational institutions and to assess their impact on international IT law.</td></tr>
<tr><td>Links to other Modules within the Study Program
This module is similar to other modules in the field of Law</td><td>Links to other Study Programs of the University
All Master Programs in the Management field</td></tr>
</table>

International IT Law

Course Code: DLMIMWITR01_E

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

Course Description

This course presents in depth national and international legal framework conditions of information processing for companies. After an examination of the differences between international legal systems, an introduction is given to those legal constructs which serve as a basis for the development of IT-relevant legislation. Subsequently, areas of law are discussed from the perspective of concrete application-oriented business scenarios, such as contract law, licensing and patenting.An introduction to the EU legal system is followed by a detailed discussion of the European General Data Protection Regulation (GDPR), which gains increasingly international interest. This leads into a consideration of transnational legal systems and concludes with recommendations from supranational organizations.

Course Outcomes

On successful completion, students will be able to

- identify and explain the differences between national, transnational and international legal systems.
- identify interfaces between general legal concepts and IT-relevant law.
- identify legal requirements for IT contracting and assess their impact on the (electronic) commercialization of IT products or services.
- assess the impact of the European Data Protection Regulation on business processes and make recommendations for implementation.
- identify the legal views of selected transnational institutions and to assess their impact on international IT law.

Contents

1. Introduction
   - 1.1 General Concepts of Law
   - 1.2 Areas of Law
   - 1.3 International, Transnational and EU Law
   - 1.4 Definition and Scope of IT Law
   - 1.5 International, Transnational and European IT Law
   - 1.6 Law in Cross-Border Systems

2. E-Business and E-Commerce

Literature
Compulsory Reading
Further Reading ▪ Lloyd, I. (2020): Information Technology Law. Oxford University Press. ▪ Lutzi, T. (2020): Private International Law Online: Internet Regulation and Civil Liability in the EU. Oxford University Press. ▪ Nirmal, B. C. & Singh, R. K. (ed.) (2018): Contemporary Issues in International Law. Environment, International Trade, Information Technology and Legal Education. Springer. ▪ Savin, A. (2017): EU Internet Law. Edward Elgar Publishing. ▪ Siems, M. (2018): Comparative law. Cambridge University Press. ▪ Thirlway, H. (2019): The sources of international law. Oxford University Press.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Exam, 90 Minutes

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	30 h	30 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Practice Exam
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Online Tests
☑ Recorded Live Sessions		

Seminar: Legal Framework for IT-Security

Module Code: DLMCSEEITLS1_E

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMIGCR01-01_E or DLMIGCR01-01; DLMIMWITR01_E or DLMIMWITR01	MA	5	150 h

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

Module Coordinator

Dr. Mohammad Shackow (Seminar: Legal Framework for IT-Security)

Contributing Courses to Module

- Seminar: Legal Framework for IT-Security (DLMCSEEITLS01_E)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

Compliance with the law is a major driver of security in organizations. The student must understand the various legal frameworks and jurisdictions that may apply to her/his work. Law also plays a role in pursuing criminals that attack an organization. Therefore, the support of preservation of evidence plays a key role. In this module, we explore these legal frameworks and apply them to realistic problems from the field of computer security.

Learning Outcomes	
Seminar: Legal Framework for IT-Security On successful completion, students will be able to ▪ understand how laws apply to cyberspace and IT-Security in organizations and enterprises. ▪ understand the legal limitations of pursuing criminals for law enforcement agencies and the importance of preservation of evidence. ▪ appreciate the differences in international law as applied to computer operations. ▪ understand how legal frameworks drive computer security compliance.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Law	**Links to other Study Programs of the University** All Master Programs in the Management field

Seminar: Legal Framework for IT-Security

Course Code: DLMCSEEITLS01_E

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMIGCR01-01_E or DLMIGCR01-01; DLMIMWITR01_E or DLMIMWITR01

Course Description

Computer security does not operate in a legal vacuum. It is subject to legal frameworks in regard of the applicability of international law in cyberspace, National Cyber Security strategies and national policies and legislation. Due to the global nature of Cyberspace, not limited to national boundaries, Organizations often operate in a variety of jurisdictions with a variety of laws. Criminals are using this fact by putting their key operations outside the reach of their victim's jurisdiction. State actors and non-State actors operate in legal grey zones to pursue their targets. Therefore, international organizations, such as the EU, OSCE, ASEAN, are developing compliance frameworks and mechanisms. In this seminar we examine cases and legal frameworks that IT-Security personnel has to recognize.

Course Outcomes

On successful completion, students will be able to

- understand how laws apply to cyberspace and IT-Security in organizations and enterprises.
- understand the legal limitations of pursuing criminals for law enforcement agencies and the importance of preservation of evidence.
- appreciate the differences in international law as applied to computer operations.
- understand how legal frameworks drive computer security compliance.

Contents

- Students will be given an aspect of law or a legal case to study and report on. Of particular importance is to understand what potential consequences the case or law will have on an organization and enterprises. Specific legal text or cases will be provided by the tutor but proposals by the students can be considered.

Literature
Compulsory Reading
Further Reading ▪ Clarke, R. A., & Knake, R. K. (2010). Cyber war. (1st ed.). HarperCollins. ▪ Lusthaus, J. (2018). Industry of anonymity. Harvard University Press. ▪ Schmitt, M. N. (Ed.). (2017). Tallinn Manual 2.0 on the international law applicable to cyber operations. Cambridge University Press. ▪ Schneier, B. (2015). Data and Goliath. (1st ed.). W. W. Norton & Company.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Written Assessment: Research Essay

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
120 h	0 h	30 h	0 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Slides	☑ Guideline

Internship: Master AI, Machine Learning and Data Science

Module Code: DLMMLIMAMLDS

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	MA	20	600 h

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

Module Coordinator
N.N. (Internship: Master AI, Machine Learning and Data Science)

Contributing Courses to Module
▪ Internship: Master AI, Machine Learning and Data Science (DLMMLIMAMLDS01)

Module Exam Type	
Module Exam Study Format: Distance Learning Internship Reflection Paper (passed / not passed)	**Split Exam**
Weight of Module see curriculum	

Module Contents
Within the framework of this internship, students document and reflect on their everyday practical experiences. This is based on knowledge they have acquired. Students now apply this theoretical knowledge in various fields of practice and reflect upon it.

Learning Outcomes	
Internship: Master AI, Machine Learning and Data Science On successful completion, students will be able to ▪ to transfer theoretical knowledge to practical problems. ▪ depending on the tasks undertaken, to independently address and manage practical challenges; to reflect on their success. ▪ to better assess the scope, significance, and limitations of theoretical concepts in light of practical demands. ▪ to apply the AI algorithms, Data Science methods and ML libraries appropriately according to the specific types of data and the business requirement in practices. ▪ to critically evaluate the outcome of AI /ML based data analytics results. ▪ to implement and deploy the AI models on dedicated environment based on the requirements.	
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

Internship: Master AI, Machine Learning and Data Science

Course Code: DLMMLIMAMLDS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		20	none

Course Description
Within the scope of this course, students document and reflect on their everyday practical experience, relating it to the subject-specific and related scientific knowledge bases they have previously learned and developed, as well as previously acquired skills and competencies for action. The students apply their theoretical knowledge in various practical fields and reflect upon it. The connection between theory and practice, the application of knowledge in the practical field, and the reflection of these experiences in relation to theory and personal development are the primary focus.

Course Outcomes

On successful completion, students will be able to

- to transfer theoretical knowledge to practical problems.
- depending on the tasks undertaken, to independently address and manage practical challenges; to reflect on their success.
- to better assess the scope, significance, and limitations of theoretical concepts in light of practical demands.
- to apply the AI algorithms, Data Science methods and ML libraries appropriately according to the specific types of data and the business requirement in practices.
- to critically evaluate the outcome of AI /ML based data analytics results.
- to implement and deploy the AI models on dedicated environment based on the requirements.

Contents

- As part of the internship, students document and reflect on their everyday professional experiences in the field of machine learning. The individual problems and questions that arise are reflected upon from the perspective of professional practice. This module provides students with the opportunity to apply the content they have learned in previous modules through practical reflection and to directly implement practical knowledge where it has been acquired. Various concepts and methods are concretely tested in practice and reflected upon in their specific applications. The basis for this is the documentation, evaluation, and presentation of approaches and methods in the chosen context of action.
- The internship can/should be completed in the following companies:

- Google
- Microsoft
- Facebook
- Nvidia
- OpenAI
- IBM
- Amazon
- Apple
- Adobe
- Salesforce
- Intel
- Huggingface
- Claude

Literature
Compulsory Reading
Further Reading ▪ Within the subject relation, the literature of each module in the program is relevant.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Practical Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Internship Reflection Paper (passed / not passed)

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
0 h	0 h	0 h	0 h	600 h	600 h

Instructional Methods
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions

Start Up Lab

Module Code: DLMIEESUL

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

Prof. Dr. Lena Bernhofer (Start Up Lab)

Contributing Courses to Module

- Start Up Lab (DLMIEESUL01)

Module Exam Type	
Module Exam <u>Study Format: Distance Learning</u> Portfolio	**Split Exam**
Weight of Module see curriculum	

Module Contents

Becoming one´s own boss might be the dream of many people. Having an own business idea and bring it to market realization has been the starting point of many successful businesses. The Start Up Lab supports ambitious entrepreneurs and founders in identifying market opportunities as the basis for innovative business ideas and business models. The writing of a business plan allows the students to systematically describe and structure the business idea along the various criteria to be covered in the business plan. This way, the students can experience and expand their own start up skills.

Learning Outcomes	
Start Up Lab On successful completion, students will be able to ▪ develop an own business idea and design a business model as the foundation for writing a business plan. ▪ describe the reasons for creating a business plan for different business projects as well as explain the structure, form and content of a business plan. ▪ formulate the vision, the strategic goals and the value proposition for their business project on the basis of a comprehensive business analysis. ▪ prepare a detailed financial and capital requirement plan for their business project and assess the medium- and long-term advantages and disadvantages of the selected financing. ▪ evaluate the main risks for their business project and assess them with regard to implementation. ▪ identify the different types of growth and growth strategies for the development of a business project.	
Links to other Modules within the Study Program This module is similar to other modules in the field of Business Administration & Management	**Links to other Study Programs of the University** All Master Programs in the Business field

Start Up Lab

Course Code: DLMIEESUL01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		10	none

Course Description

In this course, students learn how to present and realize a business idea systematically and in a structured manner with a business plan. A business plan is usually created when a company is founded, but is also used for other business projects such as succession planning in a company, the new development of a product, the takeover of a company or expansion abroad. In this module, the focus is on starting an own business to implement the business idea as well as possible growth strategies to expand the business. The preparation of a business plan allows students to apply business management knowledge in a systematic, integrated and practice-oriented manner. This way, the students can experience and expand their own start up skills. They are systematically guided to address all elements of a business plan in order to increase the success for the realization of a business idea. Special emphasis is placed on identifying potential risks for later implementation.

Course Outcomes

On successful completion, students will be able to

- develop an own business idea and design a business model as the foundation for writing a business plan.
- describe the reasons for creating a business plan for different business projects as well as explain the structure, form and content of a business plan.
- formulate the vision, the strategic goals and the value proposition for their business project on the basis of a comprehensive business analysis.
- prepare a detailed financial and capital requirement plan for their business project and assess the medium- and long-term advantages and disadvantages of the selected financing.
- evaluate the main risks for their business project and assess them with regard to implementation.
- identify the different types of growth and growth strategies for the development of a business project.

Contents

- Becoming one´s own boss might be the dream of many people. Having an own business idea and bring it to market realization has been the starting point of many successful companies. It is however not self-evident that a business idea reaches the level of implementation and growth. It requires goal-setting, planning, persistence, commitment, determination and calculated risk-taking to bring an idea to success. The Start Up Lab supports ambitious entrepreneurs and founders in identifying market opportunities as the basis for innovative business ideas and business models. The writing of a business plan allows the students to systematically describe and structure the business idea along the various criteria to be covered in the business plan such as strategy, market, product/service, value proposition, target customers, marketing, production, finances and risk evaluation. By doing so, the students can experience and expand their own start up skills.

Literature

Compulsory Reading

Further Reading

- Bessant, J. & Tidd, J. (2015). Innovation and Entrepreneurship. 3rd edition, John Wiley & Sons.
- Grant, A. (2016). Originals: How Non-Conformists Move the World. Viking.
- Grant, W. (2020). How to Write a Winning Business Plan: A Step-by-Step Guide to Build a Solid Foundation, Attract Investors & Achieve Success. Walter Grant.
- Hoffman, S. (2021). Surviving a Startup: Practical Strategies for Starting a Business, Overcoming Obstacles, and Coming Out on Top. Harper Collins.
- Osterwalder, A., Pigneur, Y., Bernarda, G. & Smith, A. (2010). Value Proposition Design: How to Create Products and Services Customers Want. John Wiley & Sons.

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Portfolio

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
240 h	0 h	60 h	0 h	0 h	300 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Slides	**Exam Preparation** ☑ Guideline

Case Study: Model Engineering

Module Code: DLMDSME

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSAM01, DLMDSAS01, DLMDSPWP01, DLMDSML01, DLMDSDL01	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. Gissel Velarde Perez (Case Study: Model Engineering)

Contributing Courses to Module
▪ Case Study: Model Engineering (DLMDSME01)

Module Exam Type	
Module Exam Study Format: myStudies Written Assessment: Case Study Study Format: Distance Learning Written Assessment: Case Study	**Split Exam**
Weight of Module see curriculum	

Module Contents

- Data science methodologies
- Data quality
- Feature engineering
- Feature selection
- Building a predictive model
- Avoiding common fallacies

Learning Outcomes

Case Study: Model Engineering

On successful completion, students will be able to

- understand current data science methodologies.
- devaluate the quality of the data used in data science projects.
- create new features from raw data.
- apply feature selection techniques.
- make predictive models using data science techniques.
- identify common fallacies and know 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 field of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology field

Case Study: Model Engineering

Course Code: DLMDSME01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSAM01, DLMDSAS01, DLMDSPWP01, DLMDSML01, DLMDSDL01

Course Description

The construction of data science models and applying the techniques to real-world problems requires a deep understanding of data science processes and techniques beyond the application of relevant algorithms.This course starts by introducing two commonly used data science methodologies: CRISP-DM and MS Team Data Science. Any data taken from real machines, systems, or processes will include some errors to varying degrees. This course discusses in detail how to detect and correct data quality issues, including the importance of domain knowledge in the determination of the veracity of the data.Many machine learning approaches require the creation and subsequent selection of model features which determine which part of the data are used in which way in the later modelling step. This course discusses methods to engineer and build new features from raw data and outlines statistical methods to identify the most relevant features for the given task.Finally, this course outlines strategies to avoid common fallacies when building data science models, as well as approaches to automate workflows.

Course Outcomes

On successful completion, students will be able to

- understand current data science methodologies.
- devaluate the quality of the data used in data science projects.
- create new features from raw data.
- apply feature selection techniques.
- make predictive models using data science techniques.
- identify common fallacies and know how to avoid them.

Contents

1. Data Science Methodologies
   - 1.1 CRISP-DM
   - 1.2 MS Team Data Science

2. Data Quality
   - 2.1 Evaluating data quality
   - 2.2 Using low quality data
   - 2.3 Data duality and domain knowledge

3. Feature Engineering
   - 3.1 Building new features
   - 3.2 Splitting variables
   - 3.3 Feature engineering exploiting domain knowledge

4. Feature Selection
   - 4.1 Univariate feature selection
   - 4.2 Model based feature selection

5. Building a Predictive Model
   - 5.1 Establishing a benchmark model
   - 5.2 Prediction as probabilities
   - 5.3 Interpretable machine learning and results

6. Avoiding Common Fallacies
   - 6.1 Overtraining & generalization
   - 6.2 Overfitting & Occam's Razor
   - 6.3 Workflow automation and model persistence

Literature

Compulsory Reading

Further Reading

- Geron, A. (2017). Hands-on machine learning with Scikit-Learn and TensorFlow. O'Reilly.
- Kuhn, M., & Johnson, K. (2013). Applied predictive modeling. Springer.
- Müller, A., & Guido, S. (2016). Introduction to machine learning with Python: A guide for data scientists. O'Reilly.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support ☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	**Learning Material** ☑ Course Book ☑ Video ☑ Slides	**Exam Preparation** ☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Written Assessment: Case Study

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ Course Book	☑ Online Tests
☑ Intensive Live Sessions/Learning Sprint	☑ Video	☑ Guideline
☑ Recorded Live Sessions	☑ Slides	

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. Claudia Heß (Use Case and Evaluation)

Contributing Courses to Module
▪ Use Case and Evaluation (DLMDSUCE01)

Module Exam Type	
Module Exam <u>Study Format: myStudies</u> Oral Assignment <u>Study Format: Distance Learning</u> Oral Assignment	**Split Exam**
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 field of Data Science & Artificial Intelligence	All Master Programms in the IT & Technology field

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.). Analytics Press.
- Gilliland, M., Tashman, L., & Sglavo, U. (2016). Business forecasting: Practical problems and solutions. John Wiley & Sons.
- Hyndman, R. (2018). Forecasting: Principles and practice (2nd ed.). OTexts.
- Kahneman, D. (2012). Thinking, fast and slow. Penguin Books.
- Osterwalder, A., & Pigneur, Y. (2010). Business model generation. Wiley.
- Parmenter, D. (2015). Key performance indicators: Developing, implementing, and using winning KPIs. John Wiley & Sons.

Study Format myStudies

Study Format	Course Type
myStudies	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Theory Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** yes
Type of Exam	Oral Assignment

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
110 h	0 h	20 h	20 h	0 h	150 h

Instructional Methods		
Tutorial Support	**Learning Material**	**Exam Preparation**
☑ Course Feed ☑ Intensive Live Sessions/Learning Sprint ☑ Recorded Live Sessions	☑ Course Book ☑ Video ☑ Slides	☑ Online Tests ☑ Guideline

4. Semester

Master Thesis

Module Code: MMTHE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	MA	30	900 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 (MMTHE01) ▪ Colloquium (MMTHE02)

Module Exam Type	
Module Exam	**Split Exam** Master Thesis • Study Format "Distance Learning": Master Thesis (90) • Study Format "myStudies": Master Thesis Colloquium • Study Format "Distance Learning": Colloquium (10) • Study Format "myStudies": Colloquium (10)
Weight of Module see curriculum	

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Module Contents

Master Thesis

- Master's thesis

Colloquium

- Colloquium on the Master's thesis

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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).

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Links to other Modules within the Study Program

This module is similar to other modules in the field of Methods

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Links to other Study Programs of the University

All Master Programmes in the Business field

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Master Thesis

Course Code: MMTHE01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		27	none

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 Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Master Thesis

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
810 h	0 h	0 h	0 h	0 h	810 h

Instructional Methods

Study Format myStudies

Study Format	Course Type
myStudies	Thesis Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Master Thesis

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
810 h	0 h	0 h	0 h	0 h	810 h

Instructional Methods

Colloquium

Course Code: MMTHE02

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		3	none

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 ed.). Springer Gabler.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Colloquium

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	0 h	0 h	0 h	90 h

Instructional Methods

Study Format myStudies

Study Format	Course Type
myStudies	Thesis Course

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
Type of Exam	Colloquium

Student Workload					
Self Study	**Contact Hours**	**Tutorial/Tutorial Support**	**Self Test**	**Independent Study**	**Hours Total**
90 h	0 h	0 h	0 h	0 h	90 h

Instructional Methods