MODULE HANDBOOK

Master of Science

Master Machine Learning (FS-OI-EU-MAML-120)

120 CP

Distance Learning

INTERNATIONAL
UNIVERSITY OF
APPLIED SCIENCES

Classification: Consecutive

Contents

3. Semester

1. Semester

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
Study Format: myStudies Written Assessment: Written Assignment Study Format: Distance Learning 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	Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Study Format Distance Learning

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

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	☑ Course Book ☑ Video ☑ Audio ☑ Slides	☑ Guideline

Advanced Mathematics

Module Code: DLMDSAM

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)

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

- 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	Links to other Study Programs of the University
This module is similar to other modules in the field of Methods	All Master Programmes in the Business & Management field

Advanced Mathematics

Course Code: DLMDSAM01

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 & Integration
   - 1.2 Partial Differentiation & Integration
   - 1.3 Vector Analysis
   - 1.4 Calculus of Variations
2. Integral Transformations
   - 2.1 Convolution
   - 2.2 Fourier Transformation
3. Vector Algebra
   - 3.1 Scalars and Vectors
   - 3.2 Addition, Subtraction of Vectors

3.3 Multiplication of Vectors, Vector Product, Scalar Product

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

5. Matrices and Vector Spaces
   - 5.1 Basic Matrix Algebra
   - 5.2 Determinant, Trace, Transpose, Complex, and Hermitian Conjugates
   - 5.3 Eigenvectors and Eigenvalues
   - 5.4 Diagonalization
   - 5.5 Tensors

6. Information Theory
   - 6.1 MSE
   - 6.2 Gini Index
   - 6.3 Entropy, Shannon Entropy, Kulback Leibler Distance
   - 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. – available, but it's from 2002
- Yang, X.-S. (2018). Mathematics for Civil Engineers : An Introduction. Dunedin Academic Press.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Review Book
	☑ Audio	☑ Online Tests
	☑ Slides	

Study Format Distance Learning

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

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
	☑ Video	☑ Review Book
	☑ Audio	☑ Online Tests
	☑ Slides	

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

Learning Outcomes

Machine Learning

On successful completion, students will be able to

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

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

Machine Learning

Course Code: DLMDSML01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

3.2 Logistic Regression
3.3 Quantile Regression
3.4 Multivariate Regression
3.5 Lasso & Ridge Regression

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

Information about the examination	
Examination Admission Requirements	**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
	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Audio	
	☑ Slides	

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: myStudies Advanced Workbook Study Format: Distance Learning 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	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Methods.	All Master Programmes in the Business & Management 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. Sebastopol, CA: O'Reilley Publishing. ▪ Downey, A. (2013). Think Bayes. Sebastopol, CA: O'Reilley Publishing. ▪ Downey, A. (2014). Think stats. Sebastopol, CA: O'Reilley Publishing. ▪ McKay, D. (2003). Information theory, inference and learning algorithms. Cambridge: Cambridge University Press. ▪ Reinhart, A. (2015). Statistics done wrong. San Francisco, CA: No Starch Press.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Online Tests
	☑ Slides	☑ Guideline

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Online Tests
	☑ Slides	☑ 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	Split Exam
Study Format: myStudies Oral Assignment Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

- Introduction to neural networks and deep 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 fields 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 edition. Shelter Island, NY. Manning Publications.
- Geron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. 3rd edition. Boston, MA, O'Reilly Media Inc.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. Boston, MA: MIT Press.
- Russel, S., & Norvig, P. (2022). Artificial intelligence – A modern approach (4th ed.). Essex. Pearson.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

Project: Machine Learning Libraries

Module Code: DLMMLPMLL

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

Prof. Dr. Kristina Schaaff (Project: Machine Learning Libraries)

Contributing Courses to Module

- Project: Machine Learning Libraries (DLMMLPMLL01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Portfolio	

Weight of Module

see curriculum

Module Contents

Within this project-based course, students seamlessly integrate their previously gained knowledge into real-world applications. They leverage diverse Python libraries, translating their comprehension into precisely crafted code. All relevant artifacts from use case evaluation to the outcomes are to be documented.

Learning Outcomes

Project: Machine Learning Libraries

On successful completion, students will be able to

- transfer acquired theoretical knowledge to real-world case studies.
- know frameworks and libraries for training and prediction.
- build different ML models based on different data set and use cases, demonstrating fundamental understanding of each method and model.
- explain the difference of the models and reason behind the choice on the method based on dataset and use cases.
- critically evaluate the chosen method on their suitability for the use case and data in terms of applicability, performance, limitations.
- apply acquired theoretical knowledge to solve real-world challenges, selecting the suitable methods and libraries to address practical requirements.
- identify and utilize open data sources for benchmarking model 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 Programs in the IT & Technology field

Project: Machine Learning Libraries

Course Code: DLMMLPMLL01

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

Course Description

Throughout this course, students will acquire insights into the process of applying various Machine Learning (ML) libraries, encompassing training, prediction, evaluation, and visualization / explanation. Through real-world case studies, students will learn to make informed decisions about libraries and methods, evaluate model performance, explain the model using visualization libraries, and translate theoretical knowledge into real-life scenarios.

Course Outcomes

On successful completion, students will be able to

- transfer acquired theoretical knowledge to real-world case studies.
- know frameworks and libraries for training and prediction.
- build different ML models based on different data set and use cases, demonstrating fundamental understanding of each method and model.
- explain the difference of the models and reason behind the choice on the method based on dataset and use cases.
- critically evaluate the chosen method on their suitability for the use case and data in terms of applicability, performance, limitations.
- apply acquired theoretical knowledge to solve real-world challenges, selecting the suitable methods and libraries to address practical requirements.
- identify and utilize open data sources for benchmarking model performance.

Contents

- In this course, students will demonstrate their proficiency with a range of well-known Python ML libraries. They will utilize pandas for effective data wrangling, scikit-learn for training and prediction using classical ML methods, and either TensorFlow/Keras or PyTorch for deep learning tasks. Visualizations will be crafted using seaborn, matplotlib, Tensor Board and optionally tools like LIME and SHAP for model interpretability. Furthermore, the course delves into techniques for fine-tuning hyperparameters and applying heuristics using the libraries. These concepts will be explored through real-world case studies, providing hands-on experience. Additionally, the students will be introduced students to low-code and no-code alternatives, presenting a contrast with traditional Python library coding. This exploration will encompass aspects like tuning capabilities and strategies for model/library selection. Ultimately, students will adeptly apply their theoretical foundation to effectively tackle challenges and limitations that arise in real-world applications.

Literature
Compulsory Reading
Further Reading ▪ Géron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow. O'Reilly Media. ▪ Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press. ▪ McKinney, W. (2018). Python for Data Analysis. O'Reilly Media. ▪ Molnar, C. (2020). Interpretable Machine Learning. Leanpub ▪ Raschka, S., & Mirjalili, V. (2019). Python Machine Learning. Packt Publishing.

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	**Exam Preparation** ☑ Guideline

2. Semester

Advanced Research Methods

Module Code: DLMARM

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. Tamara Wehrstein (Advanced Research Methods)

Contributing Courses to Module

- Advanced Research Methods (DLMARM01)

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

- Social Sience and Research Paradigms
- Case Study Research
- Specific Topics of Qualitative Research
- Advanced Issues of Qualitative Research Conceptualization and Data Analysis
- Underlying Assumptions of Quantitative Research: Concepts and Consequences
- Evaluation Research

Learning Outcomes

Advanced Research Methods

On successful completion, students will be able to

- understand and apply scientific methodologies in conducting empirical research.
- plan, design, and prepare research proposals.
- differentiate between different types of case studies, select and apply different data collection strategies.
- plan, conduct, and analyze case studies and surveys.
- scientifically analyze quantitative and qualitative data.
- conduct evaluation research to determine quality of 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 Methods	All Master Programmes in the Business & Management fields

Advanced Research Methods

Course Code: DLMARM01

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

- understand and apply scientific methodologies in conducting empirical research.
- plan, design, and prepare research proposals.
- differentiate between different types of case studies, select and apply different data collection strategies.
- plan, conduct, and analyze case studies and surveys.
- scientifically analyze quantitative and qualitative data.
- conduct evaluation research to determine quality of research.

Contents

1. Theoretical Background: Social Science and Research Paradigms
   - 1.1 What is a Paradigm?
   - 1.2 Empiricism
   - 1.3 Critical Rationalism
   - 1.4 Epistemological Anarchism
   - 1.5 Structural Functionalism
   - 1.6 Symbolic Interactionism
   - 1.7 Ethnomethodology
2. Case Study Research

- 2.1 Types of Case Study Research
- 2.2 Maintaining Quality in Case Study Research
- 2.3 Case Study Design
- 2.4 Implementing Case Studies
- 2.5 Analyzing Case Studies

3. Specific Topics of Qualitative Research
   - 3.1 Idea Generation
   - 3.2 Critical Incident Technique
   - 3.3 Understanding Communication: Discourse Analysis
   - 3.4 Perceiving Perception: Interpretive Phenomenological Analysis

4. Advanced Issues of Qualitative Research Conceptualizing and Data Analysis
   - 4.1 Measurement Theory
   - 4.2 Index and Scale Construction
   - 4.3 Types of Scale Construction
   - 4.4 The Problem of Nonresponse and Missing Data
   - 4.5 Implications of IT for Research Strategies

5. Underlying Assumptions of Quantitative Research: Concepts and Consequences
   - 5.1 Classical Test Theory
   - 5.2 Probabilistic Test Theory
   - 5.3 Advanced Topics of Test Theory

6. Evaluation Research
   - 6.1 What is Evaluation Research?
   - 6.2 Types of Evaluation Research
   - 6.3 Meta-Analysis
   - 6.4 Meta-Evaluation

Literature

Compulsory Reading

Further Reading

- Babbie, E. R. (2021). The practice of social research (15th ed.). Cengage Learning. - 14th ed. (2016)
- Crossman, A. (2019) How to conduct an index for research. (URL: https://www.thoughtco.com/index-for-research-3026543 [last accessed on 15.03.2023]).
- Eurostat (n.d.) Beginners: Statistical concept - Index and base year (URL: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Beginners:Statistical_concept_-_Index_and_base_year [last accessed on 15.03.2023]).
- 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 Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Big Data Technologies

Module Code: DLMDSBDT

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. Christian Müller-Kett (Big Data Technologies)

Contributing Courses to Module

- Big Data Technologies (DLMDSBDT01)

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

- Data types and data sources
- Databases
- Modern storage frameworks
- Data formats
- Distributed computing

Learning Outcomes

Big Data Technologies

On successful completion, students will be able to

- identify different types and sources of data.
- understand different database concepts.
- learn to build new database structures.
- evaluate various data storage frameworks w.r.t. project requirements.
- analyze which data format to use for a given project.
- understand what roles you could take in such projects.
- create a distributed computing environment for a given project.
- understand the ethical impact of big data technology choices.

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.

Big Data Technologies

Course Code: DLMDSBDT01

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

Course Description

Data are often considered the “new oil”, the raw material from which value is created. To harness the power of data, the data need to be stored and processed on a technical level. This course introduces the four “Vs” of data, as well as typical data sources and types. This course then discusses how data are stored in databases. Particular focus is given to database structures and different types of databases, e.g., relational, noSQL, NewSQL, and time-series.Beyond classical and modern databases, this course covers a wide range of storage frameworks such as distributed filesystems, streaming, and query frameworks. This is complemented by a detailed discussion of data storage formats ranging from classical approaches such as CSV and HDF5 to more modern approaches like Apache Arrow and Parquet.Finally, this course gives an overview of distributed computing environments based on local clusters, cloud computing facilities, and container-based approaches.

Course Outcomes

On successful completion, students will be able to

- identify different types and sources of data.
- understand different database concepts.
- learn to build new database structures.
- evaluate various data storage frameworks w.r.t. project requirements.
- analyze which data format to use for a given project.
- understand what roles you could take in such projects.
- create a distributed computing environment for a given project.
- understand the ethical impact of big data technology choices.

Contents

1. Data Types and Data Sources
   - 1.1 The 4Vs of data: volume, velocity, variety, veracity
   - 1.2 Data sources
   - 1.3 Data types
2. Databases
   - 2.1 Database structures
   - 2.2 Introduction to SQL

2.3 Relational databases
2.4 nonSQL, NewSQL databases
2.5 Timeseries DB

3. Modern data storage frameworks
3.1 Distributed Filesystems
3.2 Streaming frameworks
3.3 Query frameworks

4. Data formats
4.1 Traditional data exchange formats
4.2 Apache Arrow
4.3 Apache Parquet

5. Distributed Computing
5.1 Cluster-based approaches
5.2 Containers
5.3 Cloud-based approaches

Literature

Compulsory Reading

Further Reading

- Date, C. J. (2003). An introduction to database systems. Pearson.
- Kleppmann, M. (2017). Designing data-intensive applications. O'Reilly.
- Wiese, L. (2015). Advanced data management. De Gruyter.

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Study Format Distance Learning

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

Information about the examination	
Examination Admission Requirements	**Online Tests:** no
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	☑ Guideline
☑ Creative Lab	☑ Reader	
	☑ Video	

Data Modeling and Reporting

Module Code: DLMBIDMR

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. Silke Vaas (Data Modeling and Reporting)

Contributing Courses to Module

- Data Modeling and Reporting (DLMBIDMR01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Basic Concepts
- Data Modeling Life Cycle
- Data Model Types
- Data Extraction Using SQL
- NoSQL Data Extraction
- Data Reporting
- Online Transactional Processing
- Online Analytical Processing

Learning Outcomes

Data Modeling and Reporting

On successful completion, students will be able to

- discuss the basic concepts of data modeling.
- comprehend the life cycle of data modeling.
- understand the different data model types.
- summarize the main SQL and NoSQL data extraction techniques.
- explain the main methods of online transaction processing.
- describe the main concepts of online analytical processing.
- explain what needs to be considered when providing a wide variety of data types with regard to data protection.
- explain which disciplines play an essential role in the context of applied data modeling and reporting.

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

Data Modeling and Reporting

Course Code: DLMBIDMR01

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

Course Description

Interdisciplinary working methods and ways of thinking are often decisive for the success of sustainable IT solutions. The topic of business intelligence combines various areas from computer and natural sciences, as well as studies of business administration. This course provides an overview of data modeling and its key aspects and methods. To this end, data modeling concepts are introduced, the data modeling lifecycle is learned, and some important data modeling techniques and data extraction for SQL and NoSQL databases are presented. In addition, the concepts of online transactional processing and online analytical processing are discussed.

Course Outcomes

On successful completion, students will be able to

- discuss the basic concepts of data modeling.
- comprehend the life cycle of data modeling.
- understand the different data model types.
- summarize the main SQL and NoSQL data extraction techniques.
- explain the main methods of online transaction processing.
- describe the main concepts of online analytical processing.
- explain what needs to be considered when providing a wide variety of data types with regard to data protection.
- explain which disciplines play an essential role in the context of applied data modeling and reporting.

Contents

1. Basic Concepts
   - 1.1 Batch Data Processing
   - 1.2 Relational Data
   - 1.3 Non-Relational Data
   - 1.4 Streaming Data
   - 1.5 Big Data
2. Data Modeling Life Cycle
   - 2.1 Understand the Business
   - 2.2 Acquire and Explore Data

8.2 Basic Analytical Operations
8.3 Types of OLAP Systems
8.4 Multidimensional Processing
8.5 Hybrid Processin

Literature

Compulsory Reading

Further Reading

- Agiledata. (2021). Data Modeling 101. http://agiledata.org/essays/dataModeling101.html
- Jukic, N., Vrbsky, S., & Nestorov, S. (2016). Database Systems, Introduction to Databases and Data Warehouses. Prospect Press.
- Meier, A., & Kaufmann, M. (2019). SQL & NoSQL Databases - Models, Languages, Consistency Options and Architectures for Big Data Management. Springer.
- Molinaro, A., & de Graaf, R. (2020). SQL Cookbook: Query Solutions and Techniques for All SQL Users. O'Reilly UK Ltd.
- Vasilik, S. M. (2020). SQL Practice Problems: 57 beginning, intermediate, and advanced challenges for you to solve using a “learn-by-doing” approach.

Study Format Distance Learning

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

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
	☑ Audio	
	☑ Slides	

Seminar: Sustainability, Ethics, and Law in Machine Learning

Module Code: DLMMLSSELML

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

Prof. Dr. Kristina Schaaff (Seminar: Sustainability, Ethics, and Law in Machine Learning)

Contributing Courses to Module

- Seminar: Sustainability, Ethics, and Law in Machine Learning (DLMMLSSELML01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

The seminar covers topics concerning sustainability, ethics and how international law fits in participants gain critical understanding, methods knowledge, and practical skills necessary for responsible ML usage. Guided by real-world use cases, the seminar addresses privacy, bias, transparency, legality, and societal and environmental impact. A current list of topics will be provided.

Learning Outcomes

Seminar: Sustainability, Ethics, and Law in Machine Learning

On successful completion, students will be able to

- critically reflect on current research about sustainability, ethics and international IT Law.
- grasp the socio-cultural and environmental implications of Machine Learning systems.
- be aware of international ethical best-practices in Machine Learning practices.
- identify potential areas of bias and discrimination in Machine Learning practices and research possible solutions to minimize or mitigate them.
- effectively incorporate sustainability considerations in Machine Learning projects.
- exhibit cultural competence when designing or applying Machine Learning solutions in diverse global contexts.

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

Seminar: Sustainability, Ethics, and Law in Machine Learning

Course Code: DLMMLSSELML01

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

Course Description

In this course students will gain an in-depth look at the ethical, legal, and sustainable considerations of applying Machine Learning techniques. Through interactive teaching this seminar provides knowledge of methods, critical understanding, and practical skills necessary to commit to responsible usage of Machine Learning techniques. Based on different use cases participants will be guided through issues of privacy, bias, transparency, lawfulness, and social and environmental impact of Machine Learning. Insights from several disciplines, including AI, data sciences, ethics, and law are considered to allow for a holistic understanding. A current list of topics will be provided.

Course Outcomes

On successful completion, students will be able to

- critically reflect on current research about sustainability, ethics and international IT Law.
- grasp the socio-cultural and environmental implications of Machine Learning systems.
- be aware of international ethical best-practices in Machine Learning practices.
- identify potential areas of bias and discrimination in Machine Learning practices and research possible solutions to minimize or mitigate them.
- effectively incorporate sustainability considerations in Machine Learning projects.
- exhibit cultural competence when designing or applying Machine Learning solutions in diverse global contexts.

Contents

- The seminar will provide an overview to ethics, sustainability, and law in Machine Learning. Ethical and legal implications of Machine Learning Model deployments will be discussed, e.g., how to foster technological advancement while adhering to ethical standards. A critical understanding of possible bias in Machine Learning algorithms, data quality issues, explainability methods, privacy concerns and data protection approaches will be gained. Several case studies will be discussed in detail. The following topics will be available:
  - Use cases that reflect trustworthy and fair AI models and possible implications of biased AI models.

- Use cases around sustainable development of Machine Learning; to explore the environmental and societal impact of AI models and Machine Learning with a specific focus on the sustainable development goals.
- Use cases of sustainable development of Machine Learning with a specific focus on issues around the digital divide.
- Use cases that highlight the principles of ethical decision making in machine learning, including relevant ethical frameworks for machine learning application and best practices.
- Use cases to cover international regulations and legal challenges posed by Machine Learning, considering international frameworks and possible technologies such as secure and privacy preserving Machine Learning techniques.

Literature

Compulsory Reading

Further Reading

- Hidalgo, A., Gabaly, S., Morales-Alonso, G., & Urueña, A. (2020). The digital divide in light of sustainable development: An approach through advanced machine learning techniques. Technological forecasting and social change, 150, 119754.
- Jobin, A., Ienca, M., & Vayena, E. (2019). The global landscape of AI ethics guidelines. Nature machine intelligence, 1(9), 389-399.
- Kaissis, G. A., Makowski, M. R., Rückert, D., & Braren, R. F. (2020). Secure, privacy-preserving and federated machine learning in medical imaging. Nature Machine Intelligence, 2(6), 305-311.
- Le Quy, T., Roy, A., Iosifidis, V., Zhang, W., & Ntoutsi, E. (2022). A survey on datasets for fairness-aware machine learning. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 12(3), e1452.
- Müller,V. C. (2020). Ethics of Artificial Intelligence and Robotics. In Edward Zalta (ed.), Stanford Encyclopedia of Philosophy. Palo Alto, Cal.: CSLI, Stanford University. pp. 1-70.

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	**Exam Preparation** ☑ Guideline

NLP and LLM

Module Code: DLMMLNL

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSDL01	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. Tim Schlippe (NLP and LLM)

Contributing Courses to Module

- NLP and LLM (DLMMLNL01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Natural language processing
- Large language models
- Generative Pre-trained Transformers
- Prompting

Learning Outcomes

NLP and LLM

On successful completion, students will be able to

- apply the fundamental concepts of NLP and LLM.
- analyze the different application areas of NLP and LLM.
- comprehend LLM and distilled models, including their shortcomings and developments.
- be knowledgeable about advanced prompting strategies.
- comprehend the Generative Pre-trained Transformers (GPT) and transfer 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

NLP and LLM

Course Code: DLMMLNL01

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

Course Description

The course will provide a deep dive in the topic Natural Language Processing (NLP) and specifically into Large Language Models (LLM) to cover foundational concepts and applications in the following fields: Introduction to NLP and LLM, overview of the whole landscape, purpose and application areas, including text processing and preprocessing, modelling, methods for an understanding and representation of human language, incl. n-grams, probabilistic models, neural language models, text classification and sentiment analysis, Named Entity Recognition, machine translation, text generation, LLMs foundational models, vector databases, and grounding techniques. With regard to LLM, students will gain deep insights into advanced prompting techniques, the architecture, current research topics and application fields of the Generative Pre-trained Transformers (GPT). In addition, ethical and legal aspects will be a part of the course. Throughout the course, students will engage in hands-on projects, workshops, and discussions to apply the theoretical concepts they learn to real-world scenarios. Ethical and legal considerations will be interwoven into each module to ensure that students develop a well-rounded understanding of the societal implications of NLP and LLM technologies.

Course Outcomes

On successful completion, students will be able to

- apply the fundamental concepts of NLP and LLM.
- analyze the different application areas of NLP and LLM.
- comprehend LLM and distilled models, including their shortcomings and developments.
- be knowledgeable about advanced prompting strategies.
- comprehend the Generative Pre-trained Transformers (GPT) and transfer learning.

Contents

1. Understanding NLP and LLM: Definition, Scope, and Importance
   - 1.1 Historical Evolution: Milestones and Breakthroughs in NLP and LLM
   - 1.2 Landscape Overview: Applications and Impact of NLP and LLM in Various Fields
   - 1.3 Text Processing Fundamentals: Tokenization, Stop Words, Stemming, and Lemmatization.
   - 1.4 Data Preprocessing: Cleaning, Normalization, and Handling Noisy Text Data
2. Foundations Of Language Representation

- 2.1 Probabilistic Language Models: Markov Chains, Hidden Markov Models, and N-Gram Language Models
- 2.2 Neural Language Models: Feedforward Neural Networks for Language Processing
- 2.3 Word Embeddings: Word2Vec, GloVe, and FastText for Semantic Representation
- 2.4 Transfer Learning in NLP: Pre-Trained Word Embeddings Applications
- 2.5 Text Classification and Analysis

3. Text Classification Basics: Supervised Learning, Feature Engineering, and Evaluation Metrics
   - 3.1 Sentiment Analysis Techniques
   - 3.2 Named Entity Recognition (NER): Identifying and Categorizing Named Entities
   - 3.3 Document Classification: Categorizing Textual Data
   - 3.4 Case Study: Building A Text Classification Pipeline with Real-World Data
   - 3.5 Machine Translation and Text Generation

4. Introduction To Machine Translation: Rule-Based Vs. Statistical Vs. Neural Approaches
   - 4.1 Neural Machine Translation: Encoder-Decoder Architectures and Attention Mechanisms
   - 4.2 Sequence-To-Sequence Models
   - 4.3 Text Generation Techniques: Markov Chains, Recurrent Neural Networks (rnns), and LSTMs
   - 4.4 Creative Text Generation: Challenges and Opportunities in Generating Meaningful Text
   - 4.5 LLMs Fundamentals

5. Deep Dive into LLMs: Architecture, Components, and Inner Workings
   - 5.1 Pre-Training and Fine-Tuning: Strategies for Training Effective LLMs
   - 5.2 Vector Databases and Semantic Search: Leveraging LLMs for Information Retrieval
   - 5.3 Grounding Techniques: Associating Textual Concepts with Visual and Sensory Inputs
   - 5.4 LLMs Limitations: Bias, Fairness, False Information, and Monopolies
   - 5.5 LLMs and Ethical Considerations

6. GPT Research and Prompting Techniques
   - 6.1 GPT and its Variants: Evolution and Architectural Improvements
   - 6.2 Dynamic and Adaptive Prompt Steering Strategies to Guide LLM's Output
   - 6.3 Multimodal Approaches to Prompting
   - 6.4 Current Research Trends in LLMs: Multimodal LLMs, Few-Shot Learning, and Domain Specialization
   - 6.5 Practical Applications of LLMs: Creative Writing, Code Generation, and Data Visualizations

Literature

Compulsory Reading

Further Reading

- Bian, N., Liu, P., Han, X., Lin, H., Lu, Y., He, B., & Sun, L. (2023). A drop of ink may make a million think: The spread of false information in large language models. arXiv preprint arXiv:2305.04812
- Jain, S. M. (2022). Hugging Face. Apress. https://doi-org.pxz.iubh.de:8443/10.1007/978-1-4842-8844-3_4
- Ling, C., Zhao, X., Lu, J., Deng, C., Zheng, C., Wang, J., ... & Zhao, L. (2023). Beyond One-Model-Fits-All: A Survey of Domain Specialization for Large Language Models. arXiv preprint arXiv:2305.18703.
- Liu, Y., Han, T., Ma, S., Zhang, J., Yang, Y., Tian, J., ... & Ge, B. (2023). Summary of chatgpt/gpt-4 research and perspective towards the future of large language models. arXiv preprint arXiv:2304.01852.
- Wang, Z., Valdez, J., Basu Mallick, D., & Baraniuk, R. G. (2022). Towards Human-Like Educational Question Generation with Large Language Models (Vol. 13355). Springer International Publishing.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Online Tests
	☑ 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

Dr. Anne Schwerk (Natural Language Processing)

Contributing Courses to Module

- Natural Language Processing (DLMAIWNLPVA01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Introduction to 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	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

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 fields 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	Lecture

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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 edition), Prentice-Hall.
- Hartley, R., Zisserman, A. (2004): Multiple View Geometry in Computer Vision, 2nd Edition, Cambridge University Press.
- Klette, R. (2014): Concise Computer Vision: An Introduction into Theory and Algorithms, Springer.

Study Format myStudies

Study Format	Course Type
myStudies	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Practice Exam
☑ Video	☑ Online Tests
☑ Audio	
☑ Slides	

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Practice Exam
☑ Video	☑ Online Tests
☑ Audio	
☑ 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	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Computer Science & Software Development	All Master Programs in the IT & Technology fields

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	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Practice Exam
☑ Video	☑ Online Tests
☑ Audio	
☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Practice Exam
☑ Video	☑ Online Tests
☑ Audio	
☑ Slides	

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. Andreas Schmidt (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

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.

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 Law	All Master Programs in the Business & Management fields

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
   - 2.1 General Terms and Conditions of Business
   - 2.2 Electronic Commerce
   - 2.3 IT Contracts
   - 2.4 Intermediaries and Platforms
   - 2.5 Antritrust Law and IT

3. Intellectual Property
   - 3.1 Basic Concepts of Intellectual Property
   - 3.2 Copyright
   - 3.3 Software Copyright and Software Licensing
   - 3.4 Free and Open Licensing
   - 3.5 Patenting of Software

4. Privacy and Data Protection
   - 4.1 Basic Concepts of Privacy and Data Protection
   - 4.2 European General Data Protection Regulation (GDPR)
   - 4.3 Implementation Approaches of the GDPR
   - 4.4 International Data Transfer

5. Information Security and Computer Crime
   - 5.1 Information Security Law
   - 5.2 Electronic Signatures and Digital Identities
   - 5.3 Cybercrime

6. Online Media and Telecommunication
   - 6.1 Basics of Online Media Law
   - 6.2 Social Media and Freedom of Expression
   - 6.3 Fundamentals of Telecommunications Law
   - 6.4 Internet and Domain Law

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Practice Exam
☑ Video	☑ Online Tests
☑ Audio	
☑ Slides	

Data Query Languages

Module Code: DLMDMDQL

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. Thomas Kopsch (Data Query Languages)

Contributing Courses to Module

- Data Query Languages (DLMDMDQL01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

- Definition of Data Query Languages and Typical Examples
- Different Types of Data and the Role of Databases
- Data Query Languages and Standards
- Fundamentals of SQL
- Use of Data Query Languages for NoSQL Database and other Purposes
- Data Query Languages in the Context of Application Programming

Learning Outcomes

Data Query Languages

On successful completion, students will be able to

- understand the basics of data query languages.
- understand different data structuring options and types of data sources.
- explain the difference between various data query languages, their application and their distinction from other programming languages.
- review and determine data query languages for appropriate use.
- apply and create SQL queries on self-created and given data in relational databases.
- understand the use of data query languages for application programming.

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 Query Languages

Course Code: DLMDMDQL01

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

Course Description

The course is a general introduction to data query languages and the use by application interface-oriented and programming-oriented approaches, with a focus on SQL for relational databases.

Course Outcomes

On successful completion, students will be able to

- understand the basics of data query languages.
- understand different data structuring options and types of data sources.
- explain the difference between various data query languages, their application and their distinction from other programming languages.
- review and determine data query languages for appropriate use.
- apply and create SQL queries on self-created and given data in relational databases.
- understand the use of data query languages for application programming.

Contents

1. Introduction to Data Query Languages
   - 1.1 Definition of Data Query Languages
   - 1.2 Differentiation to other Languages
   - 1.3 Typical Examples of Data Query Languages
2. Data Management
   - 2.1 Data Life Cycle
   - 2.2 Types of Datasets (Structured, Semi-Structured and Unstructured Data)
   - 2.3 Role of Databases (SQL & NoSQL Databases)
3. Fundamentals of SQL
   - 3.1 Brief Overview
   - 3.2 Data Definition Language (DDL)
   - 3.3 Data Query Language (DQL)
   - 3.4 Data Manipulation Language (DML)
4. Advanced SQL

4.1 Transaction Control Language (TCL)
4.2 Data Control Language (DCL)
4.3 Differences between various SQL Versions (MSSQL, PL/SQL, etc.)

5. Data Query Languages for NoSQL Database and other Purposes
5.1 Document Databases (N1QL/couchbase and MongoDB)
5.2 Graph Databases (Cypher/Neo4j)
5.3 GraphQL for APIs

6. Using Data Query Languages within Application Programming
6.1 Special Aspects (Architecture, Connection Management, Coding and Testing)
6.2 Examples (SQL in Python and SQL in Java)

Literature

Compulsory Reading

Further Reading

- Meier, A., & Kaufmann, M. (2019). SQL & NoSQL databases: Models, languages, consistency options and architectures for big data management (pp. 1–83). Springer Vieweg.
- Beaulieu, A. (2020). Learning SQL: Generate, manipulate, and retrieve data (3rd ed.). O'Reilly.
- Perkins, L., Wilson, J. R., & Redmond, E. (2018). Seven databases in seven weeks: A guide to modern databases and the NoSQL movement (2nd ed.). Pragmatic Bookshelf.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Business Intelligence I

Module Code: DLMDSEBA1

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. Silke Vaas (Business Intelligence I)

Contributing Courses to Module

- Business Intelligence I (DLMDSEBA01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Written Assessment: Case Study Study Format: myStudies *Type of examination*	

Weight of Module

see curriculum

Module Contents

- Data acquisition and dissemination
- Data warehouse and multidimensional modeling
- Analytical systems
- Future Business Intelligence Application Areas

Learning Outcomes

Business Intelligence I

On successful completion, students will be able to

- understand the motivations and use cases for, as well as fundamentals of, business intelligence.
- explain relevant types of data.
- know and disambiguate techniques and methods for modeling and dissemination of data.
- expound upon the techniques and methods for the generation and storage of information.
- select apposite business intelligence methods for given requirements.
- explain current and future business intelligence application areas.

Links to other Modules within the Study Program	**Links to other Study Programs of the University**
This module is similar to other modules in the fields of Computer Science & Software Development	All Master Programs in the IT & Technology fields

Business Intelligence I

Course Code: DLMDSEBA01

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

Course Description

Business Intelligence is about the generation of information based on operational data. It is used to enable goal-oriented management practices as well as the optimization of relevant business activities. This course introduces and discusses techniques, methods, and models for data provisioning and the generation, analysis, and dissemination of information.

Course Outcomes

On successful completion, students will be able to

- understand the motivations and use cases for, as well as fundamentals of, business intelligence.
- explain relevant types of data.
- know and disambiguate techniques and methods for modeling and dissemination of data.
- expound upon the techniques and methods for the generation and storage of information.
- select apposite business intelligence methods for given requirements.
- explain current and future business intelligence application areas.

Contents

1. Motivation and Introduction
   - 1.1 Motivation and Historical Development of the Field
   - 1.2 Business Intelligence as a Framework
2. Data Provisioning
   - 2.1 Operative and Dispositive Systems
   - 2.2 The Data Warehouse Concept
   - 2.3 Architecture Variants
3. Data Warehouse
   - 3.1 The ETL-Process
   - 3.2 DWH and Data-Mart Concepts
   - 3.3 ODS and Meta-Data
4. Modeling Multidimensional Dataspaces

4.1 Data Modeling
4.2 OLAP-Cubes
4.3 Physical Storage Concepts
4.4 Star-Schema and Snowflake-Schema
4.5 Historization

5. Analytical Systems
   5.1 Freeform Data Analysis and OLAP
   5.2 Reporting Systems
   5.3 Model-Based Analytical Systems
   5.4 Concept-Oriented Systems

6. Distribution and Access
   6.1 Information Distribution
   6.2 Information Access

7. Current and Future Business Intelligence Application Areas
   7.1 Mobile Business Intelligence
   7.2 Predictive and Prescriptive Analytics
   7.3 Artificial Intelligence
   7.4 Agile Business Intelligence

Literature

Compulsory Reading

Further Reading

- Grossmann, W., Rinderle-Ma, S. (2015). Fundamentals of Business Intelligence. Berlin/ Heidelberg: Springer.
- Kolb, J. (2013). Business intelligence in plain language: A practical guide to data mining and business analytics. Createspace.
- Sharda, R., Delen, D., & Turban, E. (2014). Business intelligence and analytics: Systems for decision support. Pearson.
- Sharda, R., Delen, D., & Turban, E. (2017). Business intelligence, analytics, and data science: A managerial perspective. Pearson.
- Sherman, R. (2014). Business intelligence guidebook: From data integration to analytics. Morgan Kaufmann.
- Turban, E., Sharda, R., Aronson, J., & King, D. (2010). Business intelligence. A managerial approach (2nd ed.). Prentice Hall.
- Vaisman, A., & Zimányi, E. (2016). Data warehouse systems: Design and implementation. Springer.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Online Tests
☑ Video	☑ Guideline
☑ Audio	
☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	

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

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

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

Dr. Sahar Qaadan (Case Study: Model Engineering)

Contributing Courses to Module

- Case Study: Model Engineering (DLMDSME01)

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

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

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 Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

Learning Material
- ☑ Course Book
- ☑ Video
- ☑ Audio
- ☑ Slides

Exam Preparation
- ☑ Online Tests
- ☑ Guideline

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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

Learning Material
- ☑ Course Book
- ☑ Video
- ☑ Audio
- ☑ Slides

Exam Preparation
- ☑ Online Tests
- ☑ Guideline

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

Prof. Dr. Thomas Zöller (Explainable and Interpretable Machine Learning Models)

Contributing Courses to Module

- Explainable and Interpretable Machine Learning Models (DLMMLEIMLM01)

Module Exam Type

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

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 Al models. Also, they learn about the reliability of Al 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 Al, 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	Online Lecture

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
	☑ Video	☑ Online Tests
	☑ Slides	☑ Guideline

3. Semester

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

Dr. Anne Schwerk (Voice Assistants)

Contributing Courses to Module

- Voice Assistants (DLMAIWNLPVA02)

Module Exam Type

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

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	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ 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	☑ Slides	☑ Guideline

Project: Prompt Engineering

Module Code: DLMMLPPE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	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

(Project: Prompt Engineering)

Contributing Courses to Module

- Project: Prompt Engineering (DLMMLPPE01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Portfolio	

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

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

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	Split Exam
Study Format: Distance Learning Oral Assignment	

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

3.3 CNN Based Methods

4. Tracking
   - 4.1 Kalman Filters
   - 4.2 Particle Filters
   - 4.3 Tracking Via Deep Networks

5. Shape
   - 5.1 Shape from X
   - 5.2 Geometric Methods
   - 5.3 Radiometric Approaches

Literature

Compulsory Reading

Further Reading

- Davies, E.R. (2012). Computer and Machine Vision. 4th edition. Academic Press. London, Oxford, Boston, New York and San Diego.
- Forsyth, D., Ponce, J. (2012): Computer Vision - A Modern Approach, Prentice Hall.
- 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	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Online Tests
☑ Video	☑ Guideline
☑ Audio	
☑ Slides	

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. Leonardo Riccardi (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

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.

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.

Computer Vision for Autonomous Systems

Course Code: DLMAIEFSCVAS02

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

1. Image Formation & Acquisition
   - 1.1 Light
   - 1.2 Color
   - 1.3 Perspective Camera
   - 1.4 Camera Calibration
   - 1.5 Single and Multiple View Geometry
2. Sensors for Computer Vision
   - 2.1 Camera & Night Vision
   - 2.2 Lidar
   - 2.3 Radar
   - 2.4 Ultrasound

2.5 Trends

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

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

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

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

Literature

Compulsory Reading

Further Reading

- Ansari, S. (2020). Building Computer Vision Applications Using Artificial Neural Networks. Apress. https://doi.org/10.1007/978-1-4842-5887-3
- Ayyadevara, V., & Reddy, Y. (2020). Modern Computer Vision with PyTorch. Packt.
- 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	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Online Tests
☑ Video	☑ Guideline
☑ Audio	
☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Online Tests
☑ Video	☑ Guideline
☑ Audio	
☑ Slides	

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. Andreas Schmidt (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	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Law	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 edition, HarperCollins, New York City, NY. ▪ Lusthaus, J. (2018): Industry of Anonymity. Harvard University Press, Cambridge, MA. ▪ Schmitt, M. N. (ed.) (2017): Tallinn Manual 2.0 on the International Law Applicable to Cyber Operations. Cambridge University Press, Cambridge. ▪ Schneier, B. (2015): Data and Goliath. 1st edition, W. W. Norton & Company, New York City, NY.

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	
Learning Material	**Exam Preparation**
☑ Slides	☑ Guideline

Cyber Security and Data Protection

Module Code: DLMCSITSDP

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. Ralf Kneuper (Cyber Security and Data Protection)

Contributing Courses to Module

- Cyber Security and Data Protection (DLMCSITSDP01)

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

- Data protection and privacy
- Cyber security building blocks
- Cyber security management
- Cryptography concepts
- Cryptography applications

Learning Outcomes

Cyber Security and Data Protection

On successful completion, students will be able to

- explain the core concepts of cyber security, data protection, and cryptography including their differences and relationships.
- compare the approaches to data protection within in different legal systems.
- apply data protection concepts to data science and other application scenarios.
- analyze application scenarios to identify the adequate cyber security management measures that should be implemented.
- explain the different approaches to data protection in different cultures.

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

Cyber Security and Data Protection

Course Code: DLMCSITSDP01

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

Course Description

With the increasing digitization and networking of IT systems, the need for safeguarding systems and the data processed by these systems has grown. The aim of this module is to provide an understanding of security measures needed, cyber security including cryptography, and data protection. While the need for cyber security is similar around the world, different cultures have different expectations regarding data protection and privacy. Nevertheless, personal data are often processed outside the country where the affected individuals live. Hence, the cultural aspects of data protection need to be taken into account wherever the data are processed. This course provides an overview of the main cyber security measures in different application scenarios, as well as their integration into an Information Security Management System, with particular focus on the relevant ISO/IEC 270xx family of standards. Cryptography provides an important tool set for cyber security and is used in many different application scenarios such as secure Internet protocols and block chain.

Course Outcomes

On successful completion, students will be able to

- explain the core concepts of cyber security, data protection, and cryptography including their differences and relationships.
- compare the approaches to data protection within in different legal systems.
- apply data protection concepts to data science and other application scenarios.
- analyze application scenarios to identify the adequate cyber security management measures that should be implemented.
- explain the different approaches to data protection in different cultures.

Contents

1. Foundations of Data Protection and Cyber Security
   - 1.1 Terminology and Risk Management
   - 1.2 Core Concepts of Cyber Security
   - 1.3 Core Concepts of Data Protection and Privacy
   - 1.4 Core Concepts of Cryptography
   - 1.5 Legal Aspects
2. Data Protection

- 2.1 Basic Concepts of Data Protection (ISO/IEC 29100, Privacy by Design)
- 2.2 Data Protection in Europe: the GDPR
- 2.3 Data Protection in the USA
- 2.4 Data Protection in Asia

3. Applying Data Protection
   - 3.1 Anonymity and Pseudonyms (k-Anonymity, i-Diversity, Differential Privacy)
   - 3.2 Data Protection in Data Science and Big Data
   - 3.3 User Tracking in Online Marketing
   - 3.4 Cloud Computing

4. Building Blocks of Cyber Security
   - 4.1 Authentication, Access Management and Control
   - 4.2 Cyber Security in Networks
   - 4.3 Developing Secure IT Systems (OWASP, etc.)

5. Cyber Security Management
   - 5.1 Security Policy
   - 5.2 Security and Risk Analysis
   - 5.3 The ISO 270xx Series
   - 5.4 IT Security and IT Governance
   - 5.5 Example: Cyber Security for Credit Cards (PCI DSS)

6. Cryptography
   - 6.1 Symmetric Cryptography
   - 6.2 Asymmetric Cryptography
   - 6.3 Hash Functions
   - 6.4 Secure Data Exchange (Diffie-Hellman, Perfect Forward Secrecy, etc.)

7. Cryptographic Applications
   - 7.1 Digital Signatures
   - 7.2 Electronic Money
   - 7.3 Secure Internet Protocols (TLS, IPSec, etc.)
   - 7.4 Block Chain

Literature
Compulsory Reading
Further Reading ▪ Amoroso, E., & Amoroso, M. (2017). From CIA to APT: An introduction to cyber security. Independently published. ▪ National Institute of Standards and Technology. (2018). Framework for improving critical infrastructure cybersecurity. ▪ Paar, C., & Pelzl, J. (2011). Understanding cryptography: A textbook for students and practitioners. Springer. ▪ Walker, B. (2019). Cyber security comprehensive beginners guide to learn the basics and effective methods of cyber security. Independently published.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

Extract, Transform and Load Technologies

Module Code: DLMBIETLT

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMDSEBA01, DLMDMDQL01	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 (Extract, Transform and Load Technologies)

Contributing Courses to Module

- Extract, Transform and Load Technologies (DLMBIETLT01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- ETL-Process for SQL- and NoSQL Warehousing
- Main Features and Functions of ETL-Tools
- Practical Implementation Scenarios of ETL
- Common ETL Test Procedures

Learning Outcomes

Extract, Transform and Load Technologies

On successful completion, students will be able to

- illustrate and explain the general ETL process issues and its three essential steps.
- explain the main differences between SQL- and NoSQL-Warehousing.
- understand the ETL construction process for SQL- Data Warehousing and, in contrast, the main properties of NoSQL-Warehousing ETL framework.
- compare some ETL-Tools and their main features and functions.
- formulate and implement an ETL-testing use case.
- explain where to pay attention to data protection aspects within the ETL process.

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

Extract, Transform and Load Technologies

Course Code: DLMBIETLT01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMDSEBA01, DLMDMDQL01

Course Description

In order to merge and prepare data from several operational data sources, it is converted into management-relevant information via a process of targeted conversion. This is carried out using three steps (extract, transform, and load) which are collectively known as the ETL process. The modeling of the process depends, among other things, on the structure of the underlying data and can also have different structures depending on the requirements. Extensive tests are therefore an essential part of the overall concept.

Course Outcomes

On successful completion, students will be able to

- illustrate and explain the general ETL process issues and its three essential steps.
- explain the main differences between SQL- and NoSQL-Warehousing.
- understand the ETL construction process for SQL- Data Warehousing and, in contrast, the main properties of NoSQL-Warehousing ETL framework.
- compare some ETL-Tools and their main features and functions.
- formulate and implement an ETL-testing use case.
- explain where to pay attention to data protection aspects within the ETL process.

Contents

1. Introduction
   - 1.1 The Typical Real-Life ETL Cycle in the Data Warehouses
   - 1.2 Step 1: Data Extraction
   - 1.3 Step 2: Transformation
   - 1.4 Step 3: Loading
   - 1.5 SQL and NoSQL Warehousing
2. ETL-Process for SQL Data Warehousing
   - 2.1 Building Dimensions and Fact Tables
   - 2.2 Building Dimensions Referential Integrity
   - 2.3 Types of Data Sources
   - 2.4 Modeling the Extract Process
   - 2.5 Common Transformations

Literature

Compulsory Reading

Further Reading

- Berkani N. / Bellatreche L. (2017): A Variety-Sensitive ETL Processes, International Conference on Database and Expert Systems Applications, DEXA 2017: Database and Expert Systems Applications pp 201-216
- Dahaoui FZ., Demraoui L., Chbihi Louhdi M.R., Behja H. (2021) Toward Data Warehouse Modeling in the Context of Big Data. In: Saeed F., Al-Hadhrami T., Mohammed F., Mohammed E. (eds) Advances on Smart and Soft Computing. Advances in Intelligent Systems and Computing, vol 1188. Springer, Singapore.
  https://doi.org/10.1007/978-981-15-6048-4_21
  .
- Mallek H. / Ghozzi F. / Gargouri F. (2020): Towards Extract-Transform-Load Operations in a Big Data context, International Journal of Sociotechnology and Knowledge Development (IJSKD) 12(2).
- Martinez-Mosquera, D. / Lurjan-Mora, S. / Recalde, H. (2017): Conceptual modeling of Big Data extract processes. In: 2017 International Conference on Information Systems and Computer Science (INCISCOS). Edicator.
- Vaishnav P. (2009): A Survey of Extract-Transform-Load Technology, International Journal of Data Warehousing & Mining, 5(3), 1-27.
- Oditis I. / Bicevska Z. / Bicevskis J. / Karnitis G. (2018), Implementation of NoSQL-based Data Warehouses, Baltic J. Modern Computing, Vol. 6, No. 1, 45-55, https://doi.org/10.22364/bjmc.2018.6.1.04
- Vyas S. / Vaishnav P. (2017): A comparative study of various ETL process and their testing techniques in data warehouse, Jounal of Statistics and Management Systems.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

Learning Material
- ☑ Course Book
- ☑ Video
- ☑ Audio
- ☑ Slides

Exam Preparation
- ☑ Online Tests
- ☑ Guideline

Project: Extract, Transform and Load Technologies

Module Code: DLMBIESDPDWS1

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	DLMBIETLT01, DLMDSEBA01, DLMDMDQL01	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. Peter Poensgen (Project: Extract, Transform and Load Technologies)

Contributing Courses to Module

- Project: Extract, Transform and Load Technologies (DLMBIESDPDWS01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

In this course, students learn to apply the Extract, Transform and Load (ETL) methods and technologies, they learned in previous module, in a practical project.

Learning Outcomes

Project: Extract, Transform and Load Technologies

On successful completion, students will be able to

- practice and deepen the learned ETL knowledge.
- implement methods for moving data from different sources into a data warehouse.
- design a common data repository and associated ETL process for a data warehouse.
- evaluate the results of the ETL process.
- demonstrate the effective use of technical skills through documentation.
- present the main techniques of ETL and all related procedures.

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: Extract, Transform and Load Technologies

Course Code: DLMBIESDPDWS01

Study Level	Language of Instruction and Examination	Contact Hours	CP	Admission Requirements
MA	English		5	DLMBIETLT01, DLMDSEBA01, DLMDMDQL01

Course Description

The focus of this course is to apply previously acquired "Extract, Transform and Load (ETL)" knowledge to a project implementation and reflect on the results. The students will carry out the project based on a given set of requirements and document the results.

Course Outcomes

On successful completion, students will be able to

- practice and deepen the learned ETL knowledge.
- implement methods for moving data from different sources into a data warehouse.
- design a common data repository and associated ETL process for a data warehouse.
- evaluate the results of the ETL process.
- demonstrate the effective use of technical skills through documentation.
- present the main techniques of ETL and all related procedures.

Contents

- In this course, students perform and document a hands-on project using the Extract, Transform and Load (ETL) methods using the topics covered in the previous course based on a given set of requirements.

Literature

Compulsory Reading

Further Reading

- Ciampa , Brian. (2014): The Data Warehouse Workshop: Providing Practical Experience to the Aspiring ETL Developer. CreateSpace Independent Publishing.
- Guru99. (2021): ETL (Extract, Transform, and Load) Process in Data Warehouse. (URL: https://www.guru99.com/etl-extract-load-process.html)
- Kimball, Ralph / Caserta , Joe. (2007): The Data Warehouse ETL Toolkit, Practical Techniques for Extracting, Cleaning, Conforming, and Delivering Data. John Wiley & Sons, Inc.
- Panoply. (2021): 3 Ways to Build An ETL Process with Examples. (URL: https://panoply.io/data-warehouse-guide/3-ways-to-build-an-etl-process/)
- Singh , Jaiteg. (2011): Understanding ETL and Data Warehousing: Issues, Challenges and Importance. Role of ETL routines in Quality Data Warehouse Solutions. Lambert.

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	
Learning Material	**Exam Preparation**
☑ Slides	☑ Guideline

DevOps

Module Code: DLMDCCDO

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	none	BA	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. Tianxiang Lu (DevOps)

Contributing Courses to Module

- DevOps (DLMDCCDO01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

- Building and Testing
- Releases and Deployment
- Security and Maintenance
- Monitoring and Logging

Learning Outcomes

DevOps

On successful completion, students will be able to

- define DevOps and related disciplines.
- plan the building and testing process for software.
- perform software releases and deployments.
- implement the security of applications.
- understand the need for monitoring and logging.

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 Programs in the IT & Technology field(s)

DevOps

Course Code: DLMDCCDO01

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

Course Description

Software development and software maintenance used to be two different disciplines. Due to the growing complexity, interfaces, and interactions between the components, these have been combined in DevOps. DevOps engineers have a profound knowledge of software development and know how to operate the software. This course reflects the full spectrum of software DevOps starting from requirements, detailing build processes and collaboration, taking a deeper look into testing and deployment, focusing on software security until eventually finishing with monitoring and logging to ensure solid operations

Course Outcomes

On successful completion, students will be able to

- define DevOps and related disciplines.
- plan the building and testing process for software.
- perform software releases and deployments.
- implement the security of applications.
- understand the need for monitoring and logging.

Contents

1. Introduction to DevOps
   - 1.1 Term Definition
   - 1.2 Historical Development
   - 1.3 Software Getting More Complex
   - 1.4 Challenges in Deployment and Operations
   - 1.5 Security
2. Building Software
   - 2.1 Requirements
   - 2.2 Co-Development in Teams
   - 2.3 Configuration management with Git
   - 2.4 Solving Conflicts
   - 2.5 Continuous Builds

3. Testing Software
   - 3.1 Module Tests
   - 3.2 Integration Tests
   - 3.3 Measuring Coverage
   - 3.4 Test Automation
   - 3.5 Integrating Tests in Continuous Build
   - 3.6 User Acceptance Testing

4. Software Releases and Deployments
   - 4.1 Working With the Trunk
   - 4.2 Working With Branches
   - 4.3 Planning a Release
   - 4.4 Manual Deployment
   - 4.5 Automatic Deployment

5. Software Security
   - 5.1 Importance of Security
   - 5.2 Types of Security
   - 5.3 Security Testing
   - 5.4 Detecting Security Incidents
   - 5.5 Reacting to Security incidents

6. Monitoring and Logging
   - 6.1 Definition Monitoring
   - 6.2 Definition Logging
   - 6.3 Aggregating information
   - 6.4 Extracting KPIs
   - 6.5 Management Systems (Like Nagios)

Literature
Compulsory Reading
Further Reading ▪ Farcic, V. (2016). The DevOps 2.0 Toolkit. Packt Publishing. ▪ Forsgren, N., Kim, G., & Humble, J. (2018). Accelerate: the Science behind DevOps: building and scaling high performing technology organizations (First edition). IT Revolution Press. ▪ Gift, N., Behrman, K., Deza, A., & Gheorghiu, G. (2019). Python for DevOps: learn ruthlessly effective automation (First edition). O'Reilly. ▪ Kim, G., Willis, J., Debois, P., Allspaw, J., & Humble, J. (2016). The DevOps handbook: how to create world-class agility, reliability, and security in technology organizations (First edition). IT Revolution Press.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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	
Learning Material	**Exam Preparation**
☑ Course Book	☑ Online Tests
☑ Video	☑ Guideline
☑ Slides	

Project: Machine Learning Model Building

Module Code: DLMMLPMLMB

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	Minimaldauer: 1 Semester	WiSe/SoSe	English

Module Coordinator

(Project: Machine Learning Model Building)

Contributing Courses to Module

- Project: Machine Learning Model Building (DLMMLPMLMB01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

In this project course the students work on building a ML Model for a use case of their choosing, applying ML techniques to achieve the desired results. All relevant artifacts from use case evaluation to the outcomes are to be documented.

Learning Outcomes

Project: Machine Learning Model Building

On successful completion, students will be able to

- transfer acquired theoretical knowledge to real-world case studies.
- build ML models from the ground up, demonstrating proficiency in model architecture, feature engineering, and model training.
- explain the rationale behind choices of algorithms, frameworks, and model designs.
- critically evaluate the performance of ML models using appropriate metrics and error analysis.
- apply acquired theoretical knowledge to solve real-world case studies, adapting their models to address practical challenges.
- identify and utilize open data sources for benchmarking model performances.

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: Machine Learning Model Building

Course Code: DLMMLPMLMB01

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

Course Description

In this course, students will gain insights into the process of building, evaluating, and critically analyzing ML models. Real-world case studies will enable students to learn how to construct models from scratch, make informed choices about frameworks, assess model performance, and apply their theoretical knowledge to practical scenarios.

Course Outcomes

On successful completion, students will be able to

- transfer acquired theoretical knowledge to real-world case studies.
- build ML models from the ground up, demonstrating proficiency in model architecture, feature engineering, and model training.
- explain the rationale behind choices of algorithms, frameworks, and model designs.
- critically evaluate the performance of ML models using appropriate metrics and error analysis.
- apply acquired theoretical knowledge to solve real-world case studies, adapting their models to address practical challenges.
- identify and utilize open data sources for benchmarking model performances.

Contents

- In this course students will experience the process of building ML models, including data collection, preprocessing, model design, training, evaluation, and deployment. Students acquire knowledge on a variety of ML algorithms and their applications to understand how to select appropriate algorithms and frameworks based on problem requirements and dataset characteristics. The entire ML model pipeline will be covered, including feature engineering techniques data preprocessing, and the significance of performance metrics such as accuracy, precision, recall, and F1-score. In addition, techniques for managing class imbalance and bias will be explored through real-world case studies. Also, choosing and identifying the right benchmarking and open data sources and repositories to validate and cross-validate models will be addressed. Students will adapt their acquired theoretical knowledge to address specific challenges and constraints posed by real-world applications.

Literature
Compulsory Reading
Further Reading ▪ Callender, T., & van der Schaar, M. (2023). Automated machine learning as a partner in predictive modelling. The Lancet Digital Health, 5(5), e254-e256. ▪ Nguyen, G., Dlugolinsky, S., Bobák, M., Tran, V., López García, Á., Heredia, I., ... & Hluchý, L. (2019). Machine learning and deep learning frameworks and libraries for large-scale data mining: a survey. Artificial Intelligence Review, 52, 77-124. ▪ Wang, M., Zheng, K., Yang, Y., & Wang, X. (2020). An explainable machine learning framework for intrusion detection systems. IEEE Access, 8, 73127-73141.

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	**Exam Preparation** ☑ Guideline

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 Bachelor 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

3.2 Cognitive Processes

4. Modern AI Systems
   - 4.1 Recent Developments in Hard- and Software
   - 4.2 Narrow vs General AI
   - 4.3 NLP and Computer Vision

5. AI Application Areas
   - 5.1 Autonomous Vehicles & Mobility
   - 5.2 Personalized Medicine
   - 5.3 FinTech
   - 5.4 Retail & Industry

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	Online Lecture

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
	☑ Video	☑ Online Tests
	☑ Audio	
	☑ Slides	

Study Format myStudies

Study Format	Course Type
myStudies	Lecture

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
	☑ Video	☑ Online Tests
	☑ Audio	
	☑ Slides	

Project: AI Excellence with Creative Prompting Techniques

Module Code: DLMPAIECPT1

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

N.N. (Project: AI Excellence with Creative Prompting Techniques)

Contributing Courses to Module

- Project: AI Excellence with Creative Prompting Techniques (DLMPAIECPT01)

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

In this module, students delve into the world of generative AI applications, creating AI-generated content such as text, images, and videos. They learn to design, analyze, and evaluate different prompting techniques in these systems and apply them within their respective fields of study.

Learning Outcomes

Project: AI Excellence with Creative Prompting Techniques

On successful completion, students will be able to

- comprehend and implement various prompting techniques in generative AI applications.
- analyze, assess, and combine different prompt techniques for various expected AI outputs.
- implement ethical considerations into the design and execution of various generative AI applications.
- design, implement, and refine effective prompts and their combinations for real-world scenarios through various hands-on exercises.
- showcase creative and innovative thinking and reasoning in the application of advanced prompting techniques to solve multidimensional problems in their specialized area of study.

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: AI Excellence with Creative Prompting Techniques

Course Code: DLMPAIECPT01

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

Course Description

In this course, students explore the exciting world of prompting in various generative AI applications. They involve themselves in hands-on exercises that combine various prompting techniques to create new AI-generated content, including text, images, and videos. Through these exercises, students learn how to effectively use, analyze, combine, and assess these systems within their specialized fields of study.

Course Outcomes

On successful completion, students will be able to

- comprehend and implement various prompting techniques in generative AI applications.
- analyze, assess, and combine different prompt techniques for various expected AI outputs.
- implement ethical considerations into the design and execution of various generative AI applications.
- design, implement, and refine effective prompts and their combinations for real-world scenarios through various hands-on exercises.
- showcase creative and innovative thinking and reasoning in the application of advanced prompting techniques to solve multidimensional problems in their specialized area of study.

Contents

- In this course, students engage in a practical application of a generative AI use case by choosing from the options provided in the extensive supplementary guide. The course presents practical examples as study materials and exercises with both individual and combined prompting techniques for open-source text, image, and video generation use cases. The exercises are crafted to inspire and lead students in executing their distinct generative AI use case work and provide guidance on describing the use case and selecting a mixture of prompting techniques. Additionally, students are led to critically evaluate the design, implementation, and the outcomes from both technical and ethical perspectives.

Literature
Compulsory Reading
Further Reading ▪ Dang, H., Mecke, L., Lehmann, F., Goller, S., & Buschek, D. (2022). How to prompt? Opportunities and challenges of zero- and few-shot learning for human-AI interaction in creative applications of generative models. arXiv. https://arxiv.org/pdf/2209.01390.pdf ▪ Epstein, Z., Hertzmann, A., Herman, L., Mahari, R., Frank, M. R., Groh, M., Schroeder, H., Smith, A., Akten, M., Fjeld, J., Farid, H., Leach, N., Pentland, A. S., & Russakovsky, O. (2023). Art and the science of generative AI: A deeper dive. arXiv. https://arxiv.org/pdf/2306.04141.pdf ▪ Gozalo-Brizuela, R., & Garrido-Merchán, E. C. (2023). A survey of generative AI applications. arXiv. https://arxiv.org/pdf/2306.02781.pdf ▪ Wei, J., Wang, X., Schuurmans, D., Bosma, M. Ichter, B., Xia, F., Chi, E. H., Le., Q. V., & Zhou, D. (2023). Chain-of-though prompting elicit reasoning in large language models. arXiv. https://arxiv.org/pdf/2201.11903.pdf

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	**Exam Preparation** ☑ Guideline

Business Communication and Storytelling

Module Code: DLMCOBCST_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

Caterina Fox (Business Communication and Storytelling)

Contributing Courses to Module

- Business Communication and Storytelling (DLMCOBCST01_E)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Concept Presentation	

Weight of Module

see curriculum

Module Contents

The module will enable students to present information in an audience-centered way and to create "stories" out of numbers and data. This competence plays a significant role in an increasingly data-based world and helps to make numbers and data come alive and tangible and thus create a stronger impact internally and externally.

Learning Outcomes

Business Communication and Storytelling

On successful completion, students will be able to

- bring data to life through storytelling.
- apply storytelling methods to their own data.
- link emotions to data.
- build a presentation based on dramaturgy.
- use presentation techniques to reinforce the story.
- visualize data in an audience-centered way.

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 Business & Management	All Master Programs in the Business Administration & Management field

Business Communication and Storytelling

Course Code: DLMCOBCST01_E

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

Course Description

Never before has so much data been collected constantly and everywhere as today. On the one hand, data creates a basis for precise analysis - on the other hand, the flood of data also leads to confusion and excessive demands. Particularly in controlling, a lot of effort is put into compiling figures month after month to create analyses and forecasts and make data-driven decisions. The goal is to process data in an appealing way and to present it convincingly. This is where controllers often reach their limits, because at this point, they frequently encounter audiences who are under strong time pressure (management level), who do not have an affinity for numbers (customers) or to whom figures and plans have to be "sold" in such a way that they are willing to provide financing (banks and investors). This is where storytelling comes in handy as a method that helps to package figures and data in a story, to bring complex issues to the point and to provide them with suspense and emotions.Stories, metaphors, and the associated emotions not only focus attention, but also increase recall. They can enhance decisions by increasing persuasiveness, credibility, and trust.

Course Outcomes

On successful completion, students will be able to

- bring data to life through storytelling.
- apply storytelling methods to their own data.
- link emotions to data.
- build a presentation based on dramaturgy.
- use presentation techniques to reinforce the story.
- visualize data in an audience-centered way.

Contents

- The course covers the role of the storyteller in companies today, for executives and managers, for controllers and marketers. At the same time, aspects of creating meaning for internal and external communication through storytelling are developed. In the course, students focus on three key aspects: First, they develop instruments, methods, and concepts of storytelling and apply them. This includes the central building blocks of a story, the benefits and added value of storytelling, and fundamentals and concepts of data-based storytelling. Secondly, the students deal with options for creative visualization and design principles of data and apply these visualization techniques. The visualization approach depends on the audience and how well it supports the storyline. This includes creative

graphics for presentations, as well as effective and self-explanatory dashboard design. Third, students develop techniques and stylistic devices that authentically convey emotions and thus support the story, without appearing contrived. The learned content will be bundled and presented in a concept presentation.

Literature

Compulsory Reading

Further Reading

- Chapple, D., Pollock, N., & D'Adderio, L. (2022). From Pitching to Briefing: Extending Entrepreneurial Storytelling to New Audiences. Organization Studies, 43(5), 773–795. https://doi-org.pxz.iubh.de:8443/10.1177/01708406211024564
- Dykes, B. (2020). Effective Data Storytelling : How to Drive Change With Data, Narrative and Visuals. Wiley.
- Ikhsan, R. B., Muhammad, N. G., Faishal, M. R., Sutanto, W., Fernando, Y., & Susilo, A. (2022). Digital Storytelling and Intention to Donate Through Crowdfunding Platform. 2022 7th International Conference on Business and Industrial Research (ICBIR), Business and Industrial Research (ICBIR), 2022 7th International Conference On, 116–121. https://doi-org.pxz.iubh.de:8443/10.1109/ICBIR54589.2022.9786491
- Nussbaumer Knaflic, C. (2020). Data Storytelling - A New Trend to Improve Your Reporting. Rethinking Finance, 6, 60–65.
- Nussbaumer Knaflic, C. (2015). Storytelling With Data: A Data Visualization Guide for Business Professionals. Wiley.
- Roam, D. (2022). Tell More and Better Stories! People Grow Through Visual Storytelling (Including You). HR Future, 1, 20–23.
- Sakamoto, Y., Sallam, S., Salo, A., Leboe-McGowan, J., & Irani, P. (2022). Persuasive Data Storytelling With a Data Video During Covid-19 Infodemic: Affective Pathway to Influence the Users' Perception About Contact Tracing Apps in Less Than 6 Minutes. 2022 IEEE 15th Pacific Visualization Symposium (PacificVis), Pacific Visualization Symposium (PacificVis), 2022 IEEE 15th, PACIFICVIS, 176–180. https://doi-org.pxz.iubh.de:8443/10.1109/PacificVis53943.2022.00028
- Storr, W. & Clamp, J. (2020). The Science of Storytelling. Dreamscape Media, LLC.
- Vora, S. (2020). The Power of Data Storytelling. Sage.
- Wexler, S., Shaffer, J., & Cotgreave, A. (2017). The Big Book of Dashboards. Wiley.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

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

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	
Learning Material	**Exam Preparation**
☑ Slides	☑ Guideline

Design, Lean and Game: Social and creative methods

Module Code: DLMOMDLG_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

Prof. Dr. Anne-Kristin Langner (Design, Lean and Game: Social and creative methods)

Contributing Courses to Module

- Design, Lean and Game: Social and creative methods (DLMOMDLG01_E)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

- Agile working environments
- Business model innovation
- Design Thinking
- Lean Management
- Lean Startup
- Game Thinking
- Giving impact to customers (the crowd)

Learning Outcomes

Design, Lean and Game: Social and creative methods

On successful completion, students will be able to

- understand and analyze agile and innovative working environments.
- create agile and innovative working environments.
- evaluate and apply social and creative methods.
- evaluate and apply customer-oriented ways of thinking and working.
- build prototypes, work with toolkits and visualize processes.

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 Methods.	All Master programmes in the Business & Management fields.

Design, Lean and Game: Social and creative methods

Course Code: DLMOMDLG01_E

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

Course Description

Design, Lean and Game. Three words that sound so different, but – when it comes to their application as methods – have commonalities. They all can be characterized as social, since they consist of team- and group-oriented ways of collaboration. Furthermore, they redefine companies' views on the customer as the customer becomes part of the process or even the core of the business model. All principles can be called creative, too. Either due to the fact that they imply a hands-on-mentality, like building a prototype or working with a toolkit, or because of the idea that processes and workflows should be visualized. When it comes to agile and innovative working environments, one of these principles is often implemented. That is why the course starts with an introduction to agility and business model innovation in general followed by specific sections on Design Thinking, Lean Management, Lean Startup and Game Thinking as one of the latest concepts. Moving from general to special and back to general, the course closes with a section on the impact of the crowd (and therefore the customers). Principles like Crowdfunding or Crowdsourcing give customers a huge impact on, for instance, funding or product design processes.

Course Outcomes

On successful completion, students will be able to

- understand and analyze agile and innovative working environments.
- create agile and innovative working environments.
- evaluate and apply social and creative methods.
- evaluate and apply customer-oriented ways of thinking and working.
- build prototypes, work with toolkits and visualize processes.

Contents

1. Agility
   - 1.1 Basics
   - 1.2 Dimensions
   - 1.3 Chances and Risks
2. Business Model Innovation
   - 2.1 Basics
   - 2.2 Value Innovation

Literature
Compulsory Reading
Further Reading ▪ Helmhold, M. (2020): Lean Management and Kaizen. Fundamentals From Cases and Examples in Operations and Supply Chain Management. Springer Nature, Cham. ▪ Kim, A. J. (2018): Game Thinking: Innovate smarter & drive deep engagement with design techniques from hit games. gamethinking.io, Burlingame. ▪ Ries, E. (2017): The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Penguin, London.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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
	☑ Video	☑ Guideline
	☑ Audio	
	☑ Slides	

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	Split Exam
Study Format: Distance Learning Portfolio	

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	**Links to other Study Programs of the University**
This module is similar to other modules in the field of Business Administration & Management	All Master Programs in the Business & Management 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, Hoboken.
- Grant, A. (2016). Originals: How Non-Conformists Move the World. Viking, New York.
- 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, Grand Rapids.
- Hoffman, S. (2021). Surviving a Startup: Practical Strategies for Starting a Business, Overcoming Obstacles, and Coming Out on Top. Harper Collins, New York.
- Osterwalder, A., Pigneur, Y., Bernarda, G. & Smith, A. (2010). Value Proposition Design: How to Create Products and Services Customers Want. John Wiley & Sons, Hoboken.

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	**Learning Material**	**Exam Preparation**
☑ Course Feed	☑ 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	Minimaldauer: 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	Split Exam
Study Format: Distance Learning Internship Reflection Paper (passed / not passed)	

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

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 (90) Colloquium • Study Format "Distance Learning": Colloquium (10) • Study Format "myStudies": Colloquium (10)

Weight of Module

see curriculum

Module Contents

Master Thesis

- Master's thesis

Colloquium

- Colloquium on the Master's thesis

Learning Outcomes

Master Thesis

On successful completion, students will be able to

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

Colloquium

On successful completion, students will be able to

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

Links to other Modules within the Study Program	Links to other Study Programs of the University
This module is similar to other modules in the field(s) of Methods.	All Master Programmes in the Business & Management field(s).

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

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

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 edition, Springer Gabler, Wiesbaden.

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis Defense

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
Learning Material ☑ Slides

Study Format myStudies

Study Format	Course Type
myStudies	Thesis Defense

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
Learning Material ☑ Slides