MODULE HANDBOOK

Master of Science

Aritificial Intelligence (FI-MAAI-60)

60 ECTS

Distance Learning

INTERNATIONAL
UNIVERSITY OF
APPLIED SCIENCES

Classification: Non-consecutive

Contents

2020-06-01

1. Semester

Machine Learning

Module Code: DLMDSML

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

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

Module Coordinator

Prof. Dr. Thomas Zöller (Machine Learning)

Contributing Courses to Module

- Machine Learning (DLMDSML01)

Module Exam Type	
Module Exam Study Format: Distance Learning Exam	**Split Exam**
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 IU International University of Applied Sciences**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Machine Learning

Course Code: DLMDSML01

Study Level	Language of Instruction	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 Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

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

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
see curriculum	Minimum 1 semester	WiSe/SoSe	English

Module Coordinator

Prof. Dr. Thomas Zöller (Deep Learning)

Contributing Courses to Module

- Deep Learning (DLMDSDL01)

Module Exam Type

Module Exam	Split Exam
Study Format: Distance Learning Oral Assignment	

Weight of Module

see curriculum

Module Contents

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

Learning Outcomes	
Deep Learning On successful completion, students will be able to ▪ comprehend the fundamental building blocks of neural networks. ▪ understand concepts in deep learning. ▪ analyze the relevant deep learning architecture in a wide range of application scenarios. ▪ create deep learning models. ▪ utilize alternative methods to train deep learning models.	
Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Deep Learning

Course Code: DLMDSDL01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

Instructional Methods

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

Use Case and Evaluation

Module Code: DLMDSUCE

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

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

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

Contributing Courses to Module
▪ Use Case and Evaluation (DLMDSUCE01)

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

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

Learning Outcomes	
Use Case and Evaluation On successful completion, students will be able to ▪ analyze use cases and their requirements regarding the project objectives. ▪ apply common metrics to evaluate predictions. ▪ evaluate key performance indicators to asses projects from a business perspective. ▪ create monitoring tools that can be used to constantly evaluate the status quo of a project. ▪ understand common fallacies and how to avoid them.	
Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Use Case and Evaluation

Course Code: DLMDSUCE01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

1. Use Case Evaluation
   - 1.1 Identification of Use Cases
   - 1.2 Specifying Use Case Requirements
   - 1.3 Data Sources and Data Handling Classification

2. Model-centric Evaluation
   - 2.1 Common Metrics for Regression and Classification
   - 2.2 Visual Aides

3. Business-centric Evaluation
   - 3.1 Cost Function and Optimal Point Estimators
   - 3.2 Evaluation Using KPIs
   - 3.3 A/B Test

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

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

Reinforcement Learning

Module Code: DLMAIRIL

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

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

Module Coordinator

Prof. Dr. Ulrich Kerzel (Reinforcement Learning)

Contributing Courses to Module

- Reinforcement Learning (DLMAIRIL01)

Module Exam Type

Module Exam	Split Exam
Study Format: 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

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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.

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Links to other Modules within the Study Program

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

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Links to other Study Programs of IU International University of Applied Sciences

All Master Programmes in the IT & Technology fields

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Reinforcement Learning

Course Code: DLMAIRIL01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

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

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

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

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

Seminar: Current Topics in AI

Module Code: DLMAISCTAI

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

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

Module Coordinator

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

Contributing Courses to Module

- Seminar: Current Topics in AI (DLMAISCTAI01)

Module Exam Type

Module Exam	Split Exam
<u>Study Format: Distance Learning</u> Written Assessment: Research Essay	

Weight of Module

see curriculum

Module Contents

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

Learning Outcomes	
Seminar: Current Topics in AI On successful completion, students will be able to ▪ discuss current research trends and topics in AI. ▪ compose a theoretical essay exploring a selected topic in AI. ▪ expound upon apposite assumptions and design choices pertaining to the topic of choice. ▪ link the chosen topic to analogous approaches. ▪ identify and delineate potential uses for the chosen topic's concepts.	
Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Seminar: Current Topics in AI

Course Code: DLMAISCTAI01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Seminar

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

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

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

Project: AI Use Case

Module Code: DLMAIPAIUC

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

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

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

Contributing Courses to Module
▪ Project: AI Use Case (DLMAIPAIUC01)

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

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

Learning Outcomes	
Project: AI Use Case On successful completion, students will be able to ▪ apply the concepts covered in the preceding artificial intelligence (AI) courses to build a running AI model or system. ▪ explain the design choices made in the selection of the employed model and its implementation. ▪ transfer acquired theoretical knowledge to real-world case studies. ▪ translate the learned theories into the practice of AI system building. ▪ critically evaluate the resulting model's or system's performance.	
Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**
This module is similar to other modules in the fields of Data Science & Artificial Intelligence	All Master Programmes in the IT & Technology fields

Project: AI Use Case

Course Code: DLMAIPAIUC01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

Study Format Distance Learning

Study Format	**Course Type**
Distance Learning	Project

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

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

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

2. Semester

Computer Vision and NLP

Module Code: DLMAIECVN

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

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

Module Coordinator

Prof. Dr. Tim Schlippe (NLP and Computer Vision) / Prof. Dr. Tim Schlippe (Advanced NLP and Computer Vision)

Contributing Courses to Module

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

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

NLP and Computer Vision

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

Advanced NLP and Computer Vision

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

Learning Outcomes

NLP and Computer Vision

On successful completion, students will be able to

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

Advanced NLP and Computer Vision

On successful completion, students will be able to

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

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

NLP and Computer Vision

Course Code: DLMAINLPCV01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

1. Introduction to NLP
   - 1.1 What is NLP?
   - 1.2 Regular expressions, tokenization & stop-words
   - 1.3 Bag of Words and word vectors
   - 1.4 N-Grams: Grouping related words
   - 1.5 Word sense disambiguation
   - 1.6 NLP with Python

2. Applications of NLP
   - 2.1 Topic identification and text summary
   - 2.2 Sentiment analysis
   - 2.3 Named entity recognition
   - 2.4 Translation
   - 2.5 Chatbots

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

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

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

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

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

Advanced NLP and Computer Vision

Course Code: DLMAIEAIS01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

1. Text Processing
   - 1.1 Machine translation
   - 1.2 Information extraction

2. Speech Signal Processing
   - 2.1 Speech recognition
   - 2.2 Speech synthesis

3. Geometry Reconstruction
   - 3.1 3D reconstruction from 2D images/videos
   - 3.2 Change of perspective

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

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

Advanced Robotics 4.0

Module Code: DLMAIEAR

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

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

Module Coordinator

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

Contributing Courses to Module

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

Module Exam Type

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

Weight of Module

see curriculum

Module Contents

Industrial and Mobile Robots

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

Project: Collaborative Robotics

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

Learning Outcomes

Industrial and Mobile Robots

On successful completion, students will be able to

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

Project: Collaborative Robotics

On successful completion, students will be able to

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

Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**

Industrial and Mobile Robots

Course Code: DLMAIEAR01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

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

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

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

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

Project: Collaborative Robotics

Course Code: DLMAIEAR02

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Project

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

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

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

Applied Autonomous Driving

Module Code: DLMDSEAAD

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

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

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

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

Module Exam Type	
Module Exam	**Split Exam** <u>Architectures of Self-Driving Vehicles</u> • Study Format "Distance Learning": Exam, 90 Minutes <u>Case Study: Localization, Motion Planning and Sensor Fusion</u> • Study Format "Distance Learning": Written Assessment: Case Study
Weight of Module see curriculum	

Module Contents

Architectures of Self-Driving Vehicles

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

Case Study: Localization, Motion Planning and Sensor Fusion

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

Learning Outcomes

Architectures of Self-Driving Vehicles

On successful completion, students will be able to

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

Case Study: Localization, Motion Planning and Sensor Fusion

On successful completion, students will be able to

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

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

Architectures of Self-Driving Vehicles

Course Code: DLMDSEAAD01

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Online Lecture

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

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

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

Case Study: Localization, Motion Planning and Sensor Fusion

Course Code: DLMDSEAAD02

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

Course Description

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

Course Outcomes

On successful completion, students will be able to

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

Contents

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

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

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

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

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

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Case Study

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

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

Instructional Methods

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

Master Thesis

Module Code: DLMMTHE

Module Type	Admission Requirements	Study Level	CP	Student Workload
see curriculum	See study and exam regulation (SPO).	MA	20	600 h

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

Module Coordinator
Degree Program Advisor (SGL) (Master Thesis) / N.N. (Thesis Defence)

Contributing Courses to Module
▪ Master Thesis (DLMMTHE01) ▪ Thesis Defence (DLMMTHE02)

Module Exam Type	
Module Exam	**Split Exam** Master Thesis • Study Format "Distance Learning": Written Assessment: Master Thesis Thesis Defence • Study Format "Distance Learning": Presentation: Colloquium
Weight of Module see curriculum	

Module Contents

Master Thesis

- Written Master Thesis

Thesis Defense

Thesis Defence

Learning Outcomes

Master Thesis

On successful completion, students will be able to

- The objective of this module is the completion of a written assignment, in line with scientific methodology, that demonstrates the student's capabilities through independent investigation of a topic pertaining to the master program's area of focus.

Thesis Defence

On successful completion, students will be able to

- The main objective of the thesis defense is for the student to prove their competence in research methodology and the specific subject matter. The students should also be able to actively participate in a subject specific discussion at a higher academic level with subject area experts. Additionally, the defense will evaluate the academic presentation skills and overall communication skills of the student.

Links to other Modules within the Study Program	**Links to other Study Programs of IU International University of Applied Sciences**
This module is similar to other modules in the field of Methods.	All Master Programmes in the Business & Administration field.

Master Thesis

Course Code: DLMMTHE01

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		18	See current study and exam regulations (SPO)

Course Description

The aim of the master thesis is to effectively apply the knowledge acquired throughout the master course to an academic paper that has a thematic reference to the master program. The thesis can consist of an empirical study or theoretical research. The thesis is an independent piece of work, that, with the guidance of a supervisor, seeks to scientifically analyze and critically discuss a chosen issue, and suggest possible solutions. The chosen topic from the student's area of specialization should demonstrate their acquired competence in the functional area, yet also enrich and round out the student's scientific knowledge. This will optimally prepare the student for the needs of their future career path.

Course Outcomes

On successful completion, students will be able to

- The objective of this module is the completion of a written assignment, in line with scientific methodology, that demonstrates the student's capabilities through independent investigation of a topic pertaining to the master program's area of focus.

Contents

- The master thesis should clearly state the topic and research question, and should, through extensive research, reflect the current state of the field in question. The student should demonstrate their knowledge in the form of an independent and solution oriented paper, using theoretical and/or empirical norms.

Literature

Compulsory Reading

Further Reading

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

Study Format Distance Learning

Study Format	Course Type
Distance Learning	Thesis

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

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
540 h	0 h	0 h	0 h	0 h	540 h

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

Thesis Defence

Course Code: DLMMTHE02

Study Level	Language of Instruction	Contact Hours	CP	Admission Requirements
MA	English		2	See current study and exam regulations (SPO)

Course Description

The thesis defense takes place after the written master thesis has been handed in by the student. The examiners (the supervisor and a second examiner) will invite the student to the defense. During the presentation, the student will demonstrate that he/she personally has independently produced the content and the results of their written thesis. The thesis defense consists of a presentation where the student discusses the most significant research outcomes and the results of their thesis, followed by a question-and-answer session chaired by the examiners.

Course Outcomes

On successful completion, students will be able to

- The main objective of the thesis defense is for the student to prove their competence in research methodology and the specific subject matter. The students should also be able to actively participate in a subject specific discussion at a higher academic level with subject area experts. Additionally, the defense will evaluate the academic presentation skills and overall communication skills of the student.

Contents

- The thesis defense consists of a presentation of the results and applied method of the master thesis, followed by a question-and-answer session chaired by the examiners.

Literature

Compulsory Reading

Further Reading

- Subject specific literature chosen by the student

Study Format Distance Learning

Study Format Distance Learning	**Course Type** Thesis Defense

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

Student Workload					
Self Study	**Presence**	**Tutorial**	**Self Test**	**Practical Experience**	**Hours Total**
60 h	0 h	0 h	0 h	0 h	60 h

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