TECHNISCHE HOCHSCHULE DEGGENDORF

Module Guide
Artificial Intelligence and Data Science

Faculty Computer Science
Examination regulations 13.11.2020
Date: 04.03.2024 16:37

Table of Contents

AID-01 Artificial Intelligence and Software Development

Module code	AID-01
Module coordination	Prof. Dr. Cezar Ionescu
Course number and name	AID-01 Artificial Intelligence and Software Development
Lecturer	Prof. Dr. Cezar Ionescu
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/120
Language of Instruction	English

Module Objective

AI software development requires knowledge of multiple programming paradigms. This course introduces the students to functional, logic, and probabilistic programming with applications to AI. Students will experience each paradigm using a different programming language, but they will learn to relate them to the mainstream programming language Python.

Specifically, students will have achieved the following learning outcomes upon completion of the module:

Subject competency

- Students know and understand the the paradigms of programming used in AI
- Students explain the fundamental concepts and apply them to practical examples

Methodological competency

- Students decide which programming paradigm best fits a problem domain.
- Students design solutions using the appropriate programming paradigm
- Students implement the solution using the appropriate programming language.

Personal competency

- Students recognize the potential influence of AI in software development and can evaluate its advantages and disadvantages.

Social competency

- Students evaluate competing approaches in exercise sessions, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Programming fluency, basic notions of formal logic, undergraduate mathematics.

Learning Content

- Introduction: AI and software development
- Introduction to functional programming using Haskell
- Symbolic differentiation as an application of functional programming
- Implementing search strategies for board games
- Functional programming in Python
- Property-based testing in Haskell and Python
- Logic and functional programming: dependent types
- Logic programming and SAT/SMT solvers
- Probabilistic programming using WebPPL
- Probabilistic programming in Python

Teaching Methods

Seminar-style lectures with exercises

Remarks

This course is taught at the Deggendorf Institute of Technology

Recommended Literature

- Programming in Haskell 2nd Ed , Graham Hutton, CUP 2016
- Conceptual Programming with Python , Thorsten Alternkirch and Isaac Triguero, Lulu 2019
- Type-Driven Development with Idris , Edwin Brady, Manning 2017
- Modelling Agents with Probabilistic Programming Languages , Owain Evans et al., electronic
- SAT/SMT by Example , Dennis Yurichev, electronic

AID-02 Theoretical Fundamentals of Artificial Intelligence and Data Science

Module code	AID-02
Module coordination	Prof. Dr. Peter Faber
Course number and name	AID-02 Theoretical Fundamentals of Artificial Intelligence and Data Science
Lecturers	Prof. Dr. Peter Faber Prof. Dr. Markus Mayer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	6
ECTS	8
Workload	Time of attendance: 90 hours self-study: 150 hours Total: 240 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	8/120
Language of Instruction	English

Module Objective

In this module, students become familiar with the theoretical foundations of computer science such as:

- Formal logic,
- Probability,
- Machine models (with applications in complexity theory and predictability theory),

- Formal languages and their hierarchies.

This course lays the foundation for understanding the theoretical background for algorithms and methods inside and outside of Data Science and AI applications: Early AI systems and prominent AI examples are based on formal logic. A majority of Data Science methods directly originates from Statistics, which in turn is based on probability. This field (probability) also builds the groundwork for the most prominent modern AI and Data Science method - Machine learning. In addition, the students gain an understanding of complexity estimates and verification options, as well as the basic functions of data processing systems.

The students achieve the following learning objectives in the module:

Professional skills

The students understand the presented, theoretical fundamentals of AI and Data Science. They are able to apply these. Moreover, they can design, evaluate and improve software concepts and implementations in terms of performance. The students can formulate the mathematical details of own algorithms and can use these details to improve own implementations.

Methodological skills Through the knowledge gained in this module, students are able to grasp more advanced topics and work their way into them independently.

Soft skills The students can explain complex topics from the theoretical fundamentals of AI and Data Science and evaluate the ideas of others.

Applicability in this and other Programs

AID-14 Internship

AID-15 Faculty Elective 3 (FWPM)

AID-16 Faculty Elective 4 (FWPM)

AID-17 Advanced Topics in AI

AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

- Programming in an advanced programming language (e.g. C, C++, Java, C#)
- Mathematics of natural numbers (induction)
- Basics of propositional and predicate logic

Learning Content

Main topics:

Probability:

- Counting and sets
- Probability experiments, Toy examples (coin, dice, urn)
- Conditional probability, independence and Bayes theorem
- Discrete and continuous random variables
- Expected value, standard deviation and variance
- Central limit theorem and the Law of large numbers
- Joint distributions and independence
- Covariance and correlation

Formal logic:

- Boolean algebra
- First-order logic
- Logic proofs

Formal languages and compiler construction:

This course illuminates the theoretical background behind formal languages and language processing: Chomsky hierarchy, giving a detailled description of (non-)deterministic finite automata, regular languages, pushdown automata, context-free languages, Turing machines, recursively enumerable languages, computability (halting problem), and their applications in compiler construction -- lexer, parser, compiler frontend.

- Introduction and Translators I
- Translators II / Formal Languages I
- Formal languages II / III
- Lexical Analysis I / II
- Syntactic analysis I / II
- Syntactic analysis III / IV
- Syntax directed translation I / II
- Summary, possibly further topics (e.g. on optimizing compiler construction) - wrap-up, possibly further topics (e.g., optimizing compilers)

Teaching Methods

Seminar-style lectures with exercises

Remarks

This course is taught at the Deggendorf Institute of Technology

Recommended Literature

Probability:

The course uses the script of the MIT Open CourseWare course " Introduction To Probability And Statistics ", https://ocw.mit.edu/courses/18-05-introduction-to-probability-and-statistics-spring-2014/. The script was developed by Dr. Jeremy Orloff and Jonathan Bloom and can be downloaded under a CC license.

Formal logic:

- John Heil (2021), First-Order Logic: A Concise Introduction, Hackett Publishing Co, Indianapolis, USA
- Russell, S., Norvig, P. (2016), Artificial Intelligence - A Modern Approach, Fourth Edition. Pearson, London, GB
- Eric Steinhart (2027), More Precisely: The Math You Need to Do Philosophy, Broadview Press Ltd, Peterborough, Canada

Basic literature (Formal languages and compile building):

- John Longley, Lessons in Formal Programming Language Semantics, University of Edinburgh, 2003
- F.L. Bauer, H. Wössner: Algorithmische Sprache und Programmentwicklung, Springer Verlag 1984
- (availble also in English)
- Rudolf Berghammer: Semantik von Programmiersprachen, Logos Verlag, 2001
- Juraj Hromkovic: Theoretische Informatik, Springer Verlag
- Uwe Schöning: Theoretische Informatik - kurz gefasst. Spektrum, 2008
- Hopcroft, Motwani, Ullman: Introduction to Automata Theory, Languages, and Computation, Addison-Wesley, 2001
- Hopcroft, Motwani, Ullman: Einführung in die Automatentheorie, Formale Sprachen und Komplexitätstheorie, Pearson, 2002.
- Compilers Principles, Techniques, and Tools; Aho, Lam, Sethi, Ullmann; 2nd edition; Addison-Wesley; 2007
- Engineering a compiler; Cooper, Torczon; 2nd Edition, Morgan Kaufmann 2012
- Introduction to Automata Theory, Languages, and Comoputation; Hopcroft, Motwani, Ullman; Addison-Wesley; 2001

AID-02 Theoretical Fundamentals of Artificial Intelligence and Data Science

Type of Examination

written ex. 90 min.

AID-03 Advanced Machine Learning

Module code	AID-03
Module coordination	Prof. Dr. Christina Bauer
Course number and name	AID-03 Advanced Machine Learning
Lecturer	Prof. Dr. Christina Bauer
Semester	1
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written ex. 90 min.
Duration of Examination	90 min.
Weight	5/120
Language of Instruction	English

Module Objective

With this module, students gain expertise in the mathematical relationships in machine learning. They learn about different regression and classification models from supervised and unsupervised machine learning. Here they learn about the models in detail and how they are trained and evaluated. Through this course, students will be able to identify and troubleshoot failure cases when using machine learning. Moreover, the students gain an understanding of the description and handling of a data set for it to be used in machine learning models effectively. In summary, this course enables students to design and implement machine learning models from scratch.

The students achieve the following learning objectives in the module:
Professional skills

The students understand the presented concepts from machine learning and are able to apply these. Moreover, they can evaluate and improve machine learning models in terms of performance. The students understand the mathematical details of the machine learning models and can use these details to work on own implementations.

Methodological skills

Based on the concepts taught, students can interpret models not shown in the course and are able to understand continuative subtopics from machine learning.

Soft skills

The students can explain complex topics from machine learning and evaluate the ideas of others.

Applicability in this and other Programs

AID-14 Internship

AID-15 Faculty Elective 3 (FWPM)

AID-16 Faculty Elective 4 (FWPM)

AID-17 Advanced Topics in AI

AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

Fundamental mathematical knowledge in

- linear algebra
- analysis

Learning Content

The course contains the theoretical foundations of machine learning. The topics include:

- Model assessment: bias-variance trade-off, curse of dimensionality
- Loss functions, risks, and measures for the goodness of fit
- Universal consistency
- Lower bounds on error rates and rates of convergence
- Cross-validation, cocktail party problem
- Gradient descent optimizer
- Biased data sets: class imbalance and covariate shift
- Applications to selected machine learning methods: linear and logistic regression, neural networks, support vector machines, k-means clustering, naive bayes classification and others

Teaching Methods

Seminar-style lectures with exercises

Remarks

This course is taught at the Deggendorf Institute of Technology

Recommended Literature

- Trevor Hastie, R. Tibshirani, J. Friedman, The Elements of Statistical Learning, Springer, New York, 2009
- Stuart J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, Pearson, 2022
- Andrew Ng, CS 229 - Machine Learning, Stanford University, URL:https://see.stanford.edu/Course/CS229

AID-04 Faculty Elective 1 (FWPM)

Module code	AID-04
Module coordination	Prof. Dr. Wolfgang Dorner
Course number and name	AID-04 Faculty Elective 1 (FWPM)
Lecturer	Dozierende der ausgewählten Wahlpflichtfächer Lecturer of the chosen Electives
Semester	1
Duration of the module	1 semester
Module frequency	each semester
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weight	5/120
Language of Instruction	English

Module Objective

This module allows students to customize their curriculum by choosing an elective out of existing university courses or student research projects provided by university lecturers.

Students are allowed to select up to 2 electives from Bachelor study programs for the alignment of prior professional knowledge.

There are three main goals in this module to the benefit of each student. The first goal is to fill knowledge gaps of the student (individuality) identified by the admission test and a self-assessment by the students. The second goal is to acquire knowledge in current and different upcoming topics of AI (flexibility). In a third goal, students should be able to advance in individual higher-level AI topics (specialization). In connection with three other

electives and two language modules in the curriculum, the module offers a high degree of individuality, flexibility and specialization.

The students achieve the following learning objectives in the module:

Professional skills

The students have closed their previously identified knowledge gaps with regard to the fields of AI, mathematics for AI, data science and software development.

Methodological skills

They can apply knowledge and field-specific methods not covered by regular modules listed in this document. Also, the students collect experience in independent the work on scientific research questions.

Soft skills

The students can give constructive feedback to peers in context of peer-assessed exercises.

Since courses from other programs can be selected for the elective, the respective study and examination regulations must be consulted for module information. Further, student research projects provided by faculty staff are described by the staff once electives have to be chosen for a semester. The descriptions of university courses and projects enhance the description of this module.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Fundamental knowledge in:

- undergraduate mathematics
- undergraduate computer science
- programming languages (Python, R, Java, C, C++, C# etc.)
- literature research and scientific working

Learning Content

In the case of a course chosen as elective, the learning content follows the course content. If a student research project is selected, the student gathers knowledge from the application field of the project.

The list of electives 1 and 2 contains the following modules. A detailed description can be found on the DIT website (**https://th-deg.de/aid-m-en#subject-overview**).

- AIN-B-11 Computational Logic
- AIN-B-22 Computer Vision
- AIN-B-19 Natural Language Processing
- AIN-B-20 Human Factors and Human-Machine Interaction
- AIX-M-2 Datacenter Network Programming
- LSI-12 Data Visualisation
- HPC-M-04 Software Engineering
- HPC-M-07 High Performance Computing/Quantum Computing Technology
- AIX-M-7 Advanced Deep Learning for Robotics
- AIX-M-11 Quantum Chemistry
- AIX-M-16 ChatGPT et al.: Gernerative AI with Transformers

Students are allowed to select up to 2 electives from Bachelor study programs for the alignment of prior professional knowledge.

Teaching Methods

Course-based electives involve seminar-style lessons and may contain exercises. Student research projects rely on self-learning by doing literature research, data-science analyses and the development of algorithms or models.

Remarks

This course is taught at the Deggendorf Institute of Technology.

The type and duration of examination in this module depends on the chosen elective, such as a course or a student research project. This means that the examination can be a written/oral exam or an examination paper submitted by the student.

Recommended Literature

The fundamental literature of each elective is provided by study and examination regulation and the respective lecturer. However, this also includes literature research done by the student in case of student research projects.

AID-04 Faculty Elective 1 (FWPM)

Type of Examination

Examination form of the chosen module

AID-05 Faculty Elective 2 (FWPM)

Module code	AID-05
Module coordination	Prof. Dr. Wolfgang Dorner
Course number and name	AID-05 Faculty Elective 2 (FWPM)
Lecturer	Dozierende der ausgewählten Wahlpflichtfächer Lecturer of the chosen Electives
Semester	1
Duration of the module	1 semester
Module frequency	each semester
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weight	5/120
Language of Instruction	English

Module Objective

This module is the second elective in the M-AID curriculum.

This module allows students to customize their curriculum by choosing an elective out of existing university courses or student research projects provided by university lecturers.

Students are allowed to select up to 2 electives from Bachelor study programs for the alignment of prior professional knowledge.

There are three main goals in this module to the benefit of each student. The first goal is to fill knowledge gaps of the student (individuality) identified by the admission test and a self-assessment by the students. The second goal is to acquire knowledge in current and different upcoming topics of AI (flexibility). In a third goal, students should be able to advance in individual higher-level AI topics (specialization). In connection with three other

electives and two language modules in the curriculum, the module offers a high degree of individuality, flexibility and specialization.

The students achieve the following learning objectives in the module:

Professional skills

The students have closed their previously identified knowledge gaps with regard to the fields of AI, mathematics for AI, data science and software development.

Methodological skills

They can apply knowledge and field-specific methods not covered by regular modules listed in this document. Also, the students collect experience in independent the work on scientific research questions.

Soft skills

The students can give constructive feedback to peers in context of peer-assessed exercises.

Since courses from other programs can be selected for the elective, the respective study and examination regulations must be consulted for module information. Further, student research projects provided by faculty staff are described by the staff once electives have to be chosen for a semester. The descriptions of university courses and projects enhance the description of this module.

Applicability in this and other Programs

AID-14 Internship

AID-15 Faculty Elective 3 (FWPM)

AID-16 Faculty Elective 4 (FWPM)

AID-17 Advanced Topics in AI

AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

Fundamental knowledge in:

- undergraduate mathematics
- undergraduate computer science
- programming languages (Python, R, Java, C, C++, C# etc.)
- literature research and scientific working

Learning Content

In the case of a course chosen as elective, the learning content follows the course content. If a student research project is selected, the student gathers knowledge from the application field of the project.

The list of electives 1 and 2 contains the following modules. A detailed description can be found on the DIT website (**https://th-deg.de/aid-m-en#subject-overview**).

- AIN-B-11 Computational Logic
- AIN-B-22 Computer Vision
- AIN-B-19 Natural Language Processing
- AIN-B-20 Human Factors and Human-Machine Interaction
- AIX-M-2 Datacenter Network Programming
- LSI-12 Data Visualisation
- HPC-M-04 Software Engineering
- HPC-M-07 High Performance Computing/Quantum Computing Technology
- AIX-M-7 Advanced Deep Learning for Robotics
- AIX-M-11 Quantum Chemistry
- AIX-M-16 ChatGPT et al.: Gernerative AI with Transformers

Students are allowed to select up to 2 electives from Bachelor study programs for the alignment of prior professional knowledge.

Teaching Methods

Course-based electives involve seminar-style lessons and may contain exercises. Student research projects rely on self-learning by doing literature research, data-science analyses and the development of algorithms or models.

Remarks

This course is taught at the Deggendorf Institute of Technology.

The type and duration of examination in this module depends on the chosen elective, such as a course or a student research project. This means that the examination can be a written/oral exam or an examination paper submitted by the student.

Recommended Literature

The fundamental literature of each elective is provided by study and examination regulation and the respective lecturer. However, this also includes literature research done by the student in case of student research projects.

AID-06 Language Course: German or Czech

Module code	AID-06
Module coordination	Tanja Mertadana
Course number and name	AID-06 Language Course: German or Czech
Lecturers	Dozierende für AWP und Sprachen Tanja Mertadana
Semester	1
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	2
ECTS	2
Workload	Time of attendance: 30 hours self-study: 30 hours Total: 60 hours
Type of Examination	See examination schedule AWP and languages
Weight	2/120
Language of Instruction	German

Module Objective

The module "Language Course: German or Czech" aims to equip students with specialized language skills necessary for the independent performance in the globalized sector of Articifial Intelligence and Data Science. This module is connected with the second language course defined in module AID-13.

Which language course needs to be taken depends on the following aspects:
Students cannot enrol in a course of their native language or of a language they speak fluently (language proficiency level B2 or higher).
Czech students primarily studying in Germany need to take German as a foreign language as "Compulsory Language: German or Czech".

German students primarily studying in the Czech Republic need to take Czech as "Compulsory Language: German or Czech".
All students of other nationalities need to demonstrate a completed A1 level in either German or Czech, depending on their primary study location, by the end of the study programme. This can be achieved by successfully completing a language course for level A1 (or higher) at one of the two universities.
A minimum of 4 ECTS and maximum of 8 ECTS must/can be used for language courses. Only language courses in the respective national language of the respective university participating in the programme can be offered with certainty.

Further course objectives can be found in the corresponding course description on the homepage of the Language and Electives Centre:
https://www.th-deg.de/en/students/language-electives#languages

Applicability in this and other Programs

AID-14 Internship

Applicability of the module for other degree programmes is guaranteed.

Entrance Requirements

For advanced language courses, students have to prove the required language skills (for example through successful completion of a lower level, certificates, placement test).

Learning Content

The content can be found in the corresponding course description on the homepage of the Language and Electives Centre:
https://www.th-deg.de/en/students/language-electives#languages

Teaching Methods

Teaching and learning methods can be found in the corresponding course description on the homepage of the Language and Electives Centre:
https://www.th-deg.de/en/students/language-electives#languages

Remarks

This course is taught at Deggendorf Institute of Technology.

In all language courses a compulsory attendance of 75% is required in order to take the exam.

Recommended Literature

A list of recommended reading can be found in the corresponding course description on the homepage of the Language and Electives Centre:
https://www.th-deg.de/en/students/language-electives#languages

AID-07 Information Theory

Module code	AID-07
Module coordination	Dr.-Ing. Ivo Bukovsky
Course number and name	AID-07 Information Theory
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	3
ECTS	4
Workload	Time of attendance: 45 hours self-study: 75 hours Total: 120 hours
Type of Examination	see the USB examination schedule
Weight	4/120
Language of Instruction	English

Module Objective

This module deals with information theory and its applications. The aim of the module is for students to gain knowledge about concepts such as entropy and information, lossless data compression, communication in the presence of noise, channel capacity and channel coding and coding in graphs. Information theory is fundamental to Data Science, providing key principles for data compression, information measures, and signal processing. Its concepts are integral in machine learning, error detection and correction, and optimization strategies, underpinning the collection, analysis, and interpretation of data in various data science applications.The module includes presentations of practical applications of these concepts.

The students achieve the following learning objectives in the module:

Professional skills

- Acquire detail knowledge on fundamental data representation, encoding and transmission.
- Obtain knowledge on entropy, error detection and correction.

Methodological skills

- Students decide which data coding and compression technique best fit a problem domain.
- Students design solutions using the appropriate information technique.
- Students implement the solution using the appropriate information technique.

Personal competency

- Students recognize the potential influence of information theory and can evaluate its advantages and disadvantages.

Social competency

- Students evaluate competing approaches in exercise sessions, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Knowledge of probability and statistics.

Learning Content

1. Probability, Entropy
2. Element of the data compression, the source coding theorem
3. Symbol codes, stream Codes
4. Noisy-channel coding, communication over a noisy channel
5. - 6. Error-Correcting Codes and Real Channels
7. Coding - hash codes, binary codes
8. Good linear codes, message passing
9. - 10. Communication over Constrained Noiseless Channels
11. Elements from probability - exact marginalization (in trellises, in graphs)

12. - 13. Graph codes - low-density parity-check codes, convolutional codes, turbo codes
The content of the seminars is based on lectures. Practical tasks relating the lectures topics will be discussed at the tutorials.

Teaching Methods

- Monologic (reading, lecture, briefing)
- Work with text (with textbook, with book)
- Individual preparation for exam
- Work with multi-media resources (texts, internet, IT technologies)
- Individual tutoring
- Blended learning

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: MACKAY, David J. C. Information theory, inference, and learning algorithms. Cambridge: Cambridge University Press, 2003. ISBN 978-0-521-64298-9
- Recommended: COVER, T. M. and Joy A. THOMAS. Elements of information theory. 2nd ed. Hoboken: Wiley-Interscience, c2006. ISBN 978-0-471-24195-9
- Recommended: HOST, S. Information and Communication Theory. Hoboken, NJ: Wiley-IEEE Press, 2019. ISBN 978-1119433781
- Recommended: EL-GAMAL, A. and YOUNG-HAN, K. Network information theory. Primera. Cambridge: Cambridge University Press, 2011. ISBN 978-1-107-00873-1

AID-08 Mathematics for Artificial Intelligence and Data Science

Module code	AID-08
Module coordination	Dr.-Ing. Jan Valdman
Course number and name	AID-08 Mathematics for Artificial Intelligence and Data Science
Lecturer	Dr.-Ing. Jan Valdman
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	6
Workload	Time of attendance: 60 hours self-study: 120 hours Total: 180 hours
Type of Examination	see the USB examination schedule
Weight	6/120
Language of Instruction	English

Module Objective

This course provides basic tools from linear algebra, calculus, optimization and probability necessary for understanding algorithms in Artificial intelligence and Data Science.

The students achieve the following learning objectives in the module:

Professional skills

- Acquire detail knowledge on fundamental AI mathematics.
- Obtain knowledge on linear algebra, calculus, optimization and probability theory in AI.

Methodological skills

- Students will be able to apply the knowledge and solve mathematical problems accurately by selecting and commenting on the most appropriate alternatives and comment on the most appropriate approach.
- They can check the plausibility of the solutions found.
- Students are able to apply and implement the solutions using the appropriate technique.

Personal competency

- Students recognize the potential of mathematics in AI and can evaluate its advantages and disadvantages.

Social competency

- Students evaluate competing approaches in exercise sessions, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Knowledge of basic undergraduate mathematics and knowledge of some programming language (eg. Matlab, Python).

Learning Content

1 - Linear Algebra: matrices, linear independence, row echelon form.
2 - Analytic Geometry: norms, inner products, orthogonality, orthogonal projections.
3 - Matrix Decompositions: eigenvalues, eigenvectors, Cholesky-, eigen-, singular-decompositions.
4 - Vector Calculus: partial Differentiation and Gradients, Higher-Order Derivatives, Multivariate Taylor Series.
5 - Optimization: Gradient descent, Constrained Optimization and Lagrange Multipliers, Convex Optimization.
6 - Probability and Distributions: Bayes' Theorem, Gaussian distribution.
7 - Applications: Linear Regression, Principal Component Analysis.
The topics of tutorials follow the lecture topics.

Additional study materials:
Materials for lectures and tutorials will be in USB LMS Moodle and MS Teams

Teaching Methods

- Monologic (reading, lecture, briefing)
- E-learning

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: MARC PETER DEISENROTH, A. ALDO FAISAL, CHENG SOON ONG. Mathematics for Machine Learning, Cambridge University Press; 1st edition 2020, ISBN 978-1108470049 .
- Recommended: STEPHEN BOYD, LIEVEN VANDENBERGHE. Convex Optimization, Cambridge University Press, 1st edition 2004, ISBN: 978-0521833783 .
- Recommended: DAVID C. LAY, STEVEN R. LAY, JUDI J. MCDONALD. Linear Algebra and Its Applications, Pearson; 5th edition 2014, ISBN: 978-0321982384 .

AID-09 Computational Intelligence

Module code	AID-09
Module coordination	Dr.-Ing. Ivo Bukovsky
Course number and name	AID-09 Computational Intelligence
Lecturer	Dr.-Ing. Ivo Bukovsky
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	3
ECTS	4
Workload	Time of attendance: 45 hours self-study: 75 hours Total: 120 hours
Type of Examination	see the USB examination schedule
Weight	4/120
Language of Instruction	English

Module Objective

This course is focused on advanced topic of computation intelligence algorithms. Students obtain practical experience with advanced recurrent neural networks, reinforcement learning, fuzzy systems and nature inspired optimization. The emphasis is on practical experience and individual student projects.

The students achieve the following learning objectives in the module:

Professional skills

- Acquire practical knowledge on AI algorithms such as neural networks and reinforcement learning.

Methodological skills

- Students decide which AI algorithm best fits a problem domain.
- They can check the plausibility and effectiveness of an algorithm.

- Students are able to apply and implement the solutions using the appropriate technique.

Personal competency

- Students recognize the potential influence of different AI algorithms and can evaluate its advantages and disadvantages.
- Students are able to solve complex problems in projects.

Social competency

- Students evaluate competing approaches in exercise sessions and projects, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Basics of programming (any programming language, Python and basic knowledge of neural networks an advantage), knowledge of mathematics of basic bachelor's courses.

Learning Content

1. Introduction, overview of neural networks
2. Advanced feed-forward neural network architectures
3. Recurrent and LSTM neural networks
4. Neural Turing machines
5. Fuzzy systems and neural fuzzy systems
6. Reinforcement learning, actor-critic architecture
7. Evolutionary techniques and nature inspired optimization

The topics solved in the labs follow the lecture topics.
Students obtain their practical skills and experiences with advanced neural network architectures and nature-inspired optimization techniques in the labs. Students will benefit from commonly used neural frameworks, and they will pass through a series of laboratory tasks accomplished with a final project.

Teaching Methods

- Monologic (reading, lecture, briefing)
- Work with text (with textbook, with book)
- Work with multi-media resources (texts, internet, IT technologies)
- Individual tutoring
- Practical training
- Blended learning

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: LOTFI A ZADEH, RAFIK A ALIEV. Fuzzy Logic Theory and Applications: Part I and Part II. WSPC 2018. ISBN: 978-9813238176
- Basic: CHARU C. AGGARWAL. Neural Networks and Deep Learning: A Textbook. Springer; 1st ed. 2018. ISBN: 978-3319944623 . ISBN 978-3319944623
- Basic: SIMEON KOSTADINOV. Recurrent Neural Networks with Python Quick Start Guide: Sequential learning and language modeling with TensorFlow. Packt Publishing, 2018. ISBN: 978-1789132335
- Recommended: XIN-SHE YANG. Applied Reinforcement Learning with Python: With OpenAI Gym, Tensorflow, and Keras Paperback - Apress, 1st edition, 2019. ISBN: 978-1484251263
- Recommended: XIN-SHE YANG. Nature-Inspired Optimization Algorithms, 2nd Edition. Academic Press, September 2020. 978-0128219867

AID-10 Feature Engineering for Data Science

Module code	AID-10
Module coordination	Dr.-Ing. Ivo Bukovsky
Course number and name	AID-10 Feature Engineering for Data Science
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	3
ECTS	4
Workload	Time of attendance: 45 hours self-study: 75 hours Total: 120 hours
Type of Examination	see the USB examination schedule
Weight	4/120
Language of Instruction	English

Module Objective

The course provides students with understanding of feature engineering techniques and their use in various application domains. Students will learn the importance of feature engineering, explore feature selection techniques, and cover industrial, advanced, IoT, and bioinformatics feature engineering. Through lectures, tutorials, and case studies, students will develop the skills to transform raw data into meaningful features for data science.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

Undergraduate mathematics (linear calculus), basic programming skills (Python or other)

Learning Content

Content of lectures:
1. Introduction to Feature Engineering (FA)
2. Feature Engineering for Machine Learning Models
3. Industrial Feature Engineering
4. Advanced Feature Engineering Techniques
5. Fractal and Chaos Theory in Feature Engineering: Nonlinear Dynamics
6. Fractal and Chaos Theory in Feature Engineering
7. Fractal and Chaos Theory in Feature Engineering: Multifractals
8. Feature Engineering for IoT: Part 1
9. Feature Engineering for IoT - 2
10. Feature Engineering for IoT - 3
11. Feature Engineering for Bioinformatics - 1
12. Feature Engineering for Bioinformatics - 2
13. Feature Engineering for Bioinformatics - 3

Content of tutorials/seminar:
1. Introduction to Feature Engineering
2. Feature Engineering for Machine Learning Models
3. Industrial Feature Engineering
4. Advanced Feature Engineering Techniques
5. Fractal and Chaos Theory in Feature Engineering: Nonlinear Dynamics
6. Fractal and Chaos Theory in Feature Engineering
7. Fractal and Chaos Theory in Feature Engineering: Multifractals
8. Feature Engineering for IoT: Part 1
9. Feature Engineering for IoT - 2
10. Feature Engineering for IoT - 3
11. Feature Engineering for Bioinformatics - 1
12. Feature Engineering for Bioinformatics - 2
13. Feature Engineering for Bioinformatics - 3 and location data in

Teaching Methods

Monologic (reading, lecture, briefing)

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: Avinash Navlani, Armando Fandango, Ivan Idris: Python Data Analysis: Perform data collection, data processing, wrangling, visualization, and model building using Python, 3rd Edition, ISBN-10 1789955246, ISBN-13 978-1789955248, Publisher Packt Publishing, Publication date 2021 February 5
- Basic: MISRA, Sudip, Chandana ROY a Anandarup MUKHERJEE. Introduction to industrial internet of things and industry . ISBN 978-0-367-89758-1.
- Basic: Edgar, Gerald. Measure, topology, and fractal geometry . 1. vyd. New York : Springer, 1990. ISBN 0-387-97272-2.
- Recommended: R. P. Bonidia, D. S. Domingues, D. S. Sanches, and A. C. P. L. F. De Carvalho. MathFeature: feature extraction package for DNA, RNA and protein sequences based on mathematical descriptors, Briefings in Bioinformatics, vol. 23, no. 1, p. bbab434, Jan. 2022 .
- Recommended: Jianbo Gao, Yinhe Cao, Wen-Wen Tung, Jing Hu. Multiscale analysis of complex time series: integration of chaos and random fractal theory, and beyond, Wiley, 2007 .
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AID-11 Advanced Data Storages and Analyses

Module code	AID-11
Module coordination	Dr.-Ing. Jan Fesl
Course number and name	AID-11 Advanced Data Storages and Analyses
Lecturer	Dr.-Ing. Jan Fesl
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	6
Workload	Time of attendance: 60 hours self-study: 120 hours Total: 180 hours
Type of Examination	see the USB examination schedule
Weight	6/120
Language of Instruction	English

Module Objective

The aim of the course is to deepen students' knowledge in the field of data storage techniques and data processing. The course focuses on big data processing techniques and, data storage in non-relational databases and data analyses and mining.

The students achieve the following learning objectives in the module:

Professional skills

- Students acquire detail knowledge on storage techniques for big data.
- Learn data mining and data processing techniques from data science.
- Obtain practical knowledge of data storage and analysis techniques in AI applications.

Methodological skills

- Students decide which database type best fits a problem domain.

- Students can apply data mining and processing techniques of this module.
- Students are able to apply and implement the solutions using the appropriate technique.

Personal competency

- Students recognize the potential influence of data storage and analysis and can evaluate its advantages and disadvantages.
- Students are able to solve complex problems in exercises.

Social competency

- Students evaluate competing approaches in exercise sessions, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Knowledge of relational databases and basic knowledge of query and programming languages.

Learning Content

Content of lectures and tutorials:
1. Relational and NoSQL data storages
2. Datawarehouse
    a. Star, Snowflake and Data Vault patterns
    b. ETL, OLAP, OLTP
3. Distributed database systems
    a. CAP theorem
    b. Master-slave, mirroring, sharding
4. NoSQL database systems
    a. Key-value
    b. Column oriented
    c. Document databases
    d. Graph databases
    e. Time-series databases

5. Large datasets
    a. Velocity, variability, volume
    b. Unstructured data
    c. ELT processing, curated data
6. Stream data processing
    a. Buffering
    b. Distribution
    c. Storing
    d. Real-time processing
7. Data mining
    a. Data sources and datatypes
    b. Data matrix
    c. Data storages
8. Similarity measurement, methods of cluster analysis
9. Basic data models
    a. Linear and log-linear regression
10. Data modelling
    a. Decision trees, association rules
11. Classificatory
    a. k-NN
    b. naive bayes classifier
12. Data lakes
    a. Distributed filesystems
    b. Hadoop - family solutions

Teaching Methods

Monologic (reading, lecture, briefing)

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: C. CHURCHER. Beginning Database Design: From Novice to Professional. 1st Corrected ed., Apress 2007. ISBN: 978-1590597699
- Recommended: J. GRUS. Data Science from Scratch: First Principles with Python, 2nd Edition, O'Reilly Media 2019, ISBN: 978-1492041139
- Recommended: P.-N. TAN, M. STEINBACH, A. KARPATNE, V. KUMAR. Introduction to Data Mining (2nd edition), 2018. ISBN 978-0133128901

- Recommended: A. GORELIK. The Enterprise Big Data Lake: Delivering the Promise of Big Data and Data Science, 1st Edition, O'Reilly Media 2019, ISBN: 978-1491931554

AID-12 Parallel Programming and Computing

Module code	AID-12
Module coordination	Dr. Milan Predota
Course number and name	AID-12 Parallel Programming and Computing
Lecturer	Dr. Milan Predota
Semester	2
Duration of the module	1 semester
Module frequency	annually
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	3
ECTS	4
Workload	Time of attendance: 45 hours self-study: 75 hours Total: 120 hours
Type of Examination	see the USB examination schedule
Weight	4/120
Language of Instruction	English

Module Objective

Introduction to CPU parallelization, methods of parallelization, its HW and SW implementation using MPI and OpenMP. Quick introduction to parallelization on GPU - graphical cards. Solution of sample practical tasks, work in a parallel environment.

The students achieve the following learning objectives in the module:

Professional skills

- Students acquire detail knowledge on parallel programming and computing for AI.
- Students know how to operate the programming interfaces MPI and OpenMP.
- They obtain knowledge on GPU programming.

Methodological skills

- Students decide which of the module's techniques best fit a problem domain.
- Students can apply the techniques of this module to run algorithms on GPUs or parallelized computer clusters.

Personal competency

- Students recognize the potential influence of parallelization and can evaluate its advantages and disadvantages.
- Students are able to solve complex problems in exercises.

Social competency

- Students evaluate competing approaches in exercise sessions, offer and answer constructive criticism.

Applicability in this and other Programs

AID-14 Internship
AID-15 Faculty Elective 3 (FWPM)
AID-16 Faculty Elective 4 (FWPM)
AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Knowledge of programming in any programming language (ideally C, which is used in the course), basics of working in Linux.

Learning Content

Content of lectures:
1. Introduction to parallel computing. What is parallel computing? Why do we need parallel computers? Parallelization strategies. Acquaintance with a simple parallel program.
2.-3. MPI Parallelization, basic commands (MPI_Bcast, MPI_Reduce, MPI_Allreduce). Different ways of parallelization of cycles.
4. Communication of arrays (MPI_Scatter, MPI_Gather).
5. Commands of the C language for working with files, input/output in parallel codes, comparison of different methods.
6. Timing of the program execution, communication vs. computing time - optimization of the number of threads, efficiency.
7. Point to point parallelization in MPI, MPI_Send, MPI_Recv).
8. Commands for creation and management of MPI parallel environment, , execution of parallel tasks on multiple nodes, queue submission systems.

3. Differences in parallelization with respect to cooperation of threads during the calculation. Shared vs. distributed memory, MPI vs. OpenMP parallel environments, shared vs. private variables.
10. Parallelization in OpenMP, basic commands (pragma, parallelization of cycles, reduction).
11. Parallelization in OpenMP, advanced commands (pragma single/master, critical/ atomic/ordered, parallelization of sections).
12.-13. Programming on the graphic cards (GPU) in OpenCL, host + kernel, passing of arguments, setting number of GPU threads.
Content of tutorials/seminar:
Seminars accompany the lectures - students work on remote parallel cluster, code and execute tasks accompanying each lecture.

Teaching Methods

Monologic (reading, lecture, briefing)

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

- Basic: MICHAEL J. QUINN. Parallel Programming in C with MPI and OpenMP, McGraw Hill Higher Education, 2003
- Basic: BARBARA CHAPMAN, GABRIELE JOST, RUUD VAN DER PAS. Using OpenMP: Portable Shared Memory Parallel Programming, The MIT Press, 2007
- Recommended: GERASSIMOS BARLAS. Multicore and GPU Programming: An Integrated Approach, Morgan Kaufmann 2014, ISBN: 978-0124171374
- Recommended: WILLIAM GROPP, EWING LUSK, AND ANTHONY SKJELLUM. Using MPI - 3rd Edition: Portable Parallel Programming with the Message Passing Interface (Scientific and Engineering Computation), The MIT Press, 2014
- Recommended: " RUUD VAN DER PAS, ERIC STOTZER, CHRISTIAN TERBOVEN. Using OpenMP-The Next Step: Affinity, Accelerators, Tasking, and SIMD, MIT Press; 1st edition 2017, ISBN: 978-0262534789

AID-13 Language Course: German or Czech

Module code	AID-13
Module coordination	Tanja Mertadana
Course number and name	AID-13 Language Course: German or Czech
Lecturer	Dozierende für AWP und Sprachen
Semester	2
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	2
ECTS	2
Workload	Time of attendance: 30 hours self-study: 30 hours Total: 60 hours
Type of Examination	Examination form of the chosen module
Weight	2/120
Language of Instruction	German

Module Objective

The module "Language Course: German or Czech" aims to equip students with specialized language skills necessary for the independent performance in the globalized sector of Articifial Intelligence and Data Science. This module is connected with the second language course defined in module AID-06.

Which language course needs to be taken depends on the following aspects:
Students cannot enrol in a course of their native language or of a language they speak fluently (language proficiency level B2 or higher).
Czech students primarily studying in Germany need to take German as a foreign language as "Compulsory Language: German or Czech".
German students primarily studying in the Czech Republic need to take Czech as "Compulsory Language: German or Czech".

All students of other nationalities need to demonstrate a completed A1 level in either German or Czech, depending on their primary study location, by the end of the study programme. This can be achieved by successfully completing a language course for level A1 (or higher) at one of the two universities.
A minimum of 4 ECTS and maximum of 8 ECTS must/can be used for language courses. Only language courses in the respective national language of the respective university participating in the programme can be offered with certainty.

Further course objectives can be found in the corresponding course description of the University of South Bohemia.

Applicability in this and other Programs

AID-14 Internship

Further information can be found in the corresponding course description of the University of South Bohemia.

Entrance Requirements

Further information can be found in the corresponding course description of the University of South Bohemia.

Learning Content

The content can be found in the corresponding course description of the University of South Bohemia.

Teaching Methods

Teaching and learning methods can be found in the corresponding course description of the University of South Bohemia.

Remarks

This course is taught at the University of South Bohemia.

Recommended Literature

A list of recommended reading can be found in the corresponding course description of the University of South Bohemia.

AID-14 Internship

Module code	AID-14
Module coordination	Prof. Dr. Andreas Berl
	Germany
Course number and name	AID-14 Internship
Lecturer	Prof. Dr. Andreas Berl
Semester	3
Duration of the module	1 semester
Module frequency	as required
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	0
ECTS	20
Workload	Time of attendance: 0 hours virtual learning: 600 hours Total: 600 hours
Type of Examination	practical experience report, internship certification
Weight	20/120
Language of Instruction	English

Module Objective

The aim of the internship is to use and verify the acquired knowledge and skills in the practical conditions of a particular corporate environment. At the same time, students will test their own ability to solve a range of practical problems in the field of applied informatics. This solution of practical problems as well as understanding the connection with the operation of the company will help anchor theoretical knowledge and clarify specific areas of interest in the field of AI, data sciences and computer systems.

Part of the course is an introductory seminar for the presentation of companies, at the end of the internship students will prepare a final report as a condition for granting credit.

Internships in individual technology companies are contractually secured.

The internship is limited to 12 to 18 weeks in duration.

The students achieve the following learning objectives in the module:

Professional skills
Students understand the concepts of professional AI software creation and data science projects in industry and economics.

Methodological skills
Students have the ability to apply scientific methods of the fields of AI and data science.

Soft skills
Students know how to work in larger teams and defend the own AI-ideas against competing approaches.

Applicability in this and other Programs

AID-17 Advanced Topics in AI

AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

Students are required to take this module, if they did not complete an internship in their undergraduate or previous curricula.

For the internship, fundamental knowledge is necessary in

- mathematics
- computer science
- programming languages (Python, R, Java, C, C++, C# etc.)
- literature research and scientific working

Learning Content

The learning content of this module is based on the practical content of the internship. Depending on the tasks offered by the company, the students focus on the specific application field.

Teaching Methods

The internship should focus on self-learning. However, companies are welcome to provide initial literature references for the provided tasks or hold in-house workshops on application-specific topics, algorithms and tools in connection with the internship.

Remarks

This module is not bound to a specific study location. For more information on this module at the University of South Bohemia (USB), please refer to the M-AID module handbook of USB.

Credit is given based on attendance, evaluation of the responsible employee of the company where the internship takes place. Also, an examination paper is to be submitted by the student

Recommended Literature

Martin Gary E., Arnold B. Danzig, William F. Wright, Richard A. Flanary: School Leader Internship. Routledge, 2016

Ryan D Glick, Internship Mastery: The Technology Student's Guide to Crushing Your Internship and Launching Your Career, Glick Press, 2019

AID-15 Faculty Elective 3 (FWPM)

Module code	AID-15
Module coordination	Prof. Dr. Wolfgang Dorner
Course number and name	AID-15 Faculty Elective 3 (FWPM)
Lecturer	Dozierende der ausgewählten Wahlpflichtfächer Lecturer of the chosen Electives
Semester	3
Duration of the module	1 semester
Module frequency	each semester
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	0
ECTS	5
Workload	Time of attendance: 0 hours virtual learning: 150 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weight	5/120
Language of Instruction	English

Module Objective

This module is the third elective in the M-AID curriculum. In contrast to the faculty electives AID-04 and AID-05, electives AID-15 and AID-16 have a stronger focus on student research projects in order to strengthen independent work on scientific problems.

This module allows students to customize their curriculum by choosing an elective out of existing university courses or student research projects provided by university lecturers.

There are two main goals in this module to the benefit of each student. The first goal is to acquire knowledge in current and different upcoming topics of AI (flexibility). In a second goal, students should be able to advance in individual higher-level AI topics (specialization). In connection with three other electives and two language modules in the curriculum, the module offers a high degree of individuality, flexibility and specialization.

The students achieve the following learning objectives in the module:

Professional skills

The students have closed their previously identified knowledge gaps with regard to the fields of AI, mathematics for AI, data science and software development.

Methodological skills

They can apply knowledge and field-specific methods not covered by regular modules listed in this document. Also, the students collect experience in independent the work on scientific research questions.

Soft skills

The students can give constructive feedback to peers in context of peer-assessed exercises.

Since courses from other programs can be selected for the elective, the respective study and examination regulations must be consulted for module information. Further, student research projects provided by faculty staff are described by the staff once electives have to be chosen for a semester. The descriptions of university courses and projects enhance the description of this module.

Applicability in this and other Programs

AID-17 Advanced Topics in AI

AID-18 Master Thesis

AID-19 Master Seminar

Entrance Requirements

Fundamental knowledge in:

- undergraduate mathematics
- undergraduate computer science
- programming languages (Python, R, Java, C, C++, C# etc.)
- literature research and scientific working

Learning Content

In the case of a course chosen as elective, the learning content follows the course content. If a student research project is selected, the student gathers knowledge from the application field of the project.

The list of electives 3 and 4 contains the following modules. A detailed description can be found on the DIT website.

- AIX-M-7 Advanced Deep Learning for Robotics

- HPC-M-06 Optimization Methods
- MAI-1 Special Mathematical Methods
- AIX-M-5 Modern Internet Technologies
- LSI-1 Biomedical Data Analysis
- AIX-M-10 Imaging Physics
- AIX-M-11 Quantum Chemistry

Teaching Methods

Course-based electives involve seminar-style lessons and may contain exercises. Student research projects rely on self-learning by doing literature research, data-science analyses and the development of algorithms or models.

Remarks

This course is taught at the Deggendorf Institute of Technology.

The type and duration of examination in this module depends on the chosen elective, such as a course or a student research project. This means that the examination can be a written/oral exam or an examination paper submitted by the student.

Recommended Literature

The fundamental literature of each elective is provided by study and examination regulation and the respective lecturer. However, this also includes literature research done by the student in case of student research projects.

AID-16 Faculty Elective 4 (FWPM)

Module code	AID-16
Module coordination	Prof. Dr. Wolfgang Dorner
Course number and name	AID-16 Faculty Elective 4 (FWPM)
Lecturer	Dozierende der ausgewählten Wahlpflichtfächer Lecturer of the chosen Electives
Semester	3
Duration of the module	1 semester
Module frequency	each semester
Course type	compulsory course
Level	postgraduate
Semester periods per week (SWS)	0
ECTS	5
Workload	Time of attendance: 0 hours virtual learning: 150 hours Total: 150 hours
Type of Examination	Examination form of the chosen module
Weight	5/120
Language of Instruction	English

Module Objective

This module is the fourth elective in the M-AID curriculum. In contrast to the faculty electives AID-04 and AID-05, electives AID-15 and AID-16 have a stronger focus on student research projects in order to strengthen independent work on scientific problems.

This module allows students to customize their curriculum by choosing an elective out of existing university courses or student research projects provided by university lecturers.

There are two main goals in this module to the benefit of each student. The first goal is to acquire knowledge in current and different upcoming topics of AI (flexibility). In a second goal, students should be able to advance in individual higher-level AI topics (specialization). In connection with three other electives and two language modules in the curriculum, the module offers a high degree of individuality, flexibility and specialization.

The students achieve the following learning objectives in the module:

Professional skills

The students have closed their previously identified knowledge gaps with regard to the fields of AI, mathematics for AI, data science and software development.

Methodological skills

They can apply knowledge and field-specific methods not covered by regular modules listed in this document. Also, the students collect experience in independent the work on scientific research questions.

Soft skills

The students can give constructive feedback to peers in context of peer-assessed exercises.

Since courses from other programs can be selected for the elective, the respective study and examination regulations must be consulted for module information. Further, student research projects provided by faculty staff are described by the staff once electives have to be chosen for a semester. The descriptions of university courses and projects enhance the description of this module.

Applicability in this and other Programs

AID-17 Advanced Topics in AI
AID-18 Master Thesis
AID-19 Master Seminar

Entrance Requirements

Fundamental knowledge in:

- undergraduate mathematics
- undergraduate computer science
- programming languages (Python, R, Java, C, C++, C# etc.)
- literature research and scientific working

Learning Content

In the case of a course chosen as elective, the learning content follows the course content. If a student research project is selected, the student gathers knowledge from the application field of the project.

The list of electives 3 and 4 contains the following modules. A detailed description can be found on the DIT website.

- AIX-M-7 Advanced Deep Learning for Robotics
- HPC-M-06 Optimization Methods

- MAI-1 Special Mathematical Methods
- AIX-M-5 Modern Internet Technologies
- LSI-1 Biomedical Data Analysis
- AIX-M-10 Imaging Physics
- AIX-M-11 Quantum Chemistry

Teaching Methods

Course-based electives involve seminar-style lessons and may contain exercises. Student research projects rely on self-learning by doing literature research, data-science analyses and the development of algorithms or models.

Remarks

This course is taught at the Deggendorf Institute of Technology.

The type and duration of examination in this module depends on the chosen elective, such as a course or a student research project. This means that the examination can be a written/oral exam or an examination paper submitted by the student.

Recommended Literature

The fundamental literature of each elective is provided by study and examination regulation and the respective lecturer. However, this also includes literature research done by the student in case of student research projects.

AID-17 Advanced Topics in AI and Data Science

Module code	AID-17
Module coordination	Prof. Dr. Andreas Fischer
Course number and name	AID-17 Advanced Topics in AI and Data Science
Lecturer	Prof. Dr. Andreas Fischer
Semester	4
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	4
ECTS	5
Workload	Time of attendance: 60 hours self-study: 90 hours Total: 150 hours
Type of Examination	written student research project
Weight	5/120
Language of Instruction	English

Module Objective

The students achieve the following learning objectives in the module:

Professional skills

- Acquire detail knowledge on selected current research topics in the generic field of Artificial Intelligence and Data Science
- Obtain an overview on selected research disciplines in Artificial Intelligence and Data Science

Methodological skills

- Ability to read and understand scientific articles rapidly
- Assess the scientific quality of cutting edge research
- Present scientific results
- Put research into context

Soft skills

- Give presentations in front of a peer group
- Give and receive constructive criticism
- Participate in critical scientific discussion

Applicability in this and other Programs

This module can be used in other study programs in computer science, data science or artificial intelligence.

Entrance Requirements

- Knowledge in machine learning, deep learning, pattern recognition, natural language processing, computer vision, data science
- Courses on academic work

Learning Content

The purpose of this course is to become familiar with advanced topics in Artificial Intelligence and Data Science and to discuss cutting edge research in this field. Students will work with current scientific publications, present the relevant results, and discuss the implications of the results with their peers. Presentations are prepared individually or in small teams. By participating in intensive academic discussion, students will also have the opportunity to elaborate on their social and language skills.

Teaching Methods

Seminar

Remarks

This module is not bound to a specific study location. For more information on this module at the University of South Bohemia (USB), please refer to the M-AID module handbook of USB.

Recommended Literature

- S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach , Pearson, 2020.
- S. S. Skiena, The Data Science Design Manual , Springer, 2017.
- C. Bishop, Pattern Recognition and Machine Learning, Springer, 2006.

- I. Goodfellow, Y. Bengio and A. Courville, Deep L earning , MIT Press, 2016.

AID-18 Master Thesis

Module code	AID-18
Module coordination	Prof. Dr. Andreas Berl
Course number and name	AID-18 Master Thesis
Lecturer	Betreuer der Masterarbeit Supervisor of master thesis
Semester	4
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	0
ECTS	20
Workload	Time of attendance: 0 hours self-study: 600 hours Total: 600 hours
Type of Examination	master thesis
Weight	20/120
Language of Instruction	English

Module Objective

By producing a masters thesis, the students should demonstrate their ability to apply the knowledge and skills acquired during the M-AID curriculum, in an independently written scientific work on complex tasks. They thus demonstrate that they have successfully completed their master's levels studies and acquired the capacity for independent scientific work.
The students achieve the following learning objectives in the module:
Professional skills
Students acquire the ability to immerse themselves in tasks of a scientific and technical nature and analyze and resolve problems on their own. They are able to tackle and solve even major tasks.

Methodological skills
Using their scientific knowledge, students acquire the ability to tackle and resolve, unassisted, a large-scale issue of relevance to science in artificial intelligence and data science. The students deepen and apply the methods and instruments learned during their studies.
Soft skills
Students are able to tackle, independently and in application of self-discipline, a definable project of practical relevance to artificial intelligence and data science from a scientific perspective. The possibility of data collection and cooperation with companies opens up new experiences and career opportunities for students.

Applicability in this and other Programs

Not relevant

Entrance Requirements

There is no requirement on a certain number of ECTS credits to be collected before writing the masters thesis. However, the masters thesis should ideally be written at the end of the M-AID curriculum.

Learning Content

The master's thesis is a written report in a form of a scientific paper. It describes the scientific findings, as well as the way leading to these findings. It contains justifications for decisions regarding chosen methods for the thesis and discarded alternatives. The students own substantial contribution to the achieved results has to be evident. In addition, the student presents her or his work in a colloquium (see module AID-19), in which the scientific quality and the scientific independence of his achievements are evaluated. The work on the masters thesis is supervised by any of the instructors within the study course (professors or lecturers) or an external instructor. The masters thesis can be written on any subject or topic related to the content of the modules of the study course. The students can suggest the topics for their masters thesis according to their research or practice preferences. The preparation time of a masters thesis according to the regulations is 6 (six) months (§11 APO).

Teaching Methods

Students perform an independent, supervised scientific research work.

Up-to-date information on relevant literature and lectures on the Internet is provided via a corresponding iLearn course.

Remarks

This module is not bound to a specific study location. For more information on this module at the University of South Bohemia (USB), please refer to the M-AID module handbook of USB.

Recommended Literature

Provided by thesis supervisor and collected through own literature research.

AID-19 Master Seminar

Module code	AID-19
Module coordination	Prof. Dr. Phillipp Torkler
Course number and name	AID-19 Master Seminar
Lecturer	Prof. Dr. Phillipp Torkler
Semester	4
Duration of the module	1 semester
Module frequency	each semester
Course type	required course
Level	postgraduate
Semester periods per week (SWS)	0
ECTS	5
Workload	Time of attendance: 0 hours self-study: 150 hours Total: 150 hours
Type of Examination	colloquium
Weight	5/120
Language of Instruction	English

Module Objective

A professional delivery of scientific and technical findings during the masters thesis, to be held as presentation, is integral to the successful completion of the master degree. This includes presenting results achieved and presenting complex linkages within a tight time frame.
Students will achieve the following learning objectives:
Professional skills
Students will be able to present the at times difficult technical and scientific relationships outlined in their masters thesis to an expert audience in the form of an oral presentation, and respond to questions about their presentation at an appropriate length.
Methodological skills

Students can intelligibly convey the nature and content of the findings from their masters thesis to an expert audience and present them within a defined time frame.
Soft skills
Students are able to outline the outcomes in a presentation. The scenario of holding a presentation before an expert audience serves as a precursor to numerous similar situations students will encounter during their careers, especially with regard to time constraints and focusing on core messages; as such, this seminar prepares them for similar work-related situations.

Applicability in this and other Programs

Not relevant

Entrance Requirements

Theoretical and practical skills in presenting scientific findings are to be derived from lectures during their pre-studies (e.g. Bachelor seminar).

Learning Content

This module takes place in a collective session for all students, six weeks before the submission of the masters theses.

The preliminary outcomes of the masters thesis are outlined in oral presentations and subsequently discussed during the seminar. This helps to incorporate the audience comments into the masters thesis. Students are thus also consciously trained in presenting their findings and outcomes to experts from adjacent specialist fields within a defined short timeframe.

The length and type of presentation as well as the language used and any additional accompanying documents (handouts) that may be involved are all determined in mutual agreement with the supervisor.

The presentations are collectively discussed with students and supervisors present. Where possible and feasible, guests from participating companies and from institutes of higher education should also generally be invited.

Teaching Methods

Seminar

Remarks

This module is not bound to a specific study location. For more information on this module at the University of South Bohemia (USB), please refer to the M-AID module handbook of USB.

Recommended Literature

Up-to-date information on relevant literature and lectures on the Internet is provided via a corresponding iLearn course.