



Advanced Bayesian Data Analysis

Responsible for the Module:

Prof. Dr. Martin Lercher, Dr. Pablo Verde

Date:

18.10.2021

Lecturer(s)

Dr. Pablo Verde

Semester:

2-3

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

50 h

Self-study

100 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

each winter term

Group Size

40

Duration

1 Semester

Learning results & Competences

The course teaches the role of computer simulations and Bayesian methods for real modelling. Students that completed this module have a profound knowledge in using R and WinBUGS for Bayesian modelling.

Teaching

Lecture with theoretical and practical exercises

Content

Introduction to Bayesian hierarchical (linear and generalized) models, Bayesian inference and empirical Bayesian inference, Monte-Carlo techniques and MCMC-computations, Bayesian meta-analysis, in particular for diagnostic test data. Evidence synthesis for deterministic models. Explorative data analysis of multi-step and logitudinal data. Bayesian models for statistical regression problems. Linear regression with a large number of covariates. Variable selection. Explorative multivariate analysis. A-priori distributions for variance-covariance-matrices. Bayesian treatment of missing (random and non-random) variables. Survival modelling. Bayesian nonparametric models, mixed models. Statistical modelling with Dirichlet-process mixtures.

Prerequisites for attending**Examination**

Written exam

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Informatik

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Advanced Programming and Algorithms

Responsible for the Module:Dr. Marcel Schweitzer (marcel.schweitzer@hhu.de)**Date:**

26.01.2021

Lecturer(s)

Dr. Marcel Schweitzer, Dr. Timo Dickscheid

Semester:

1.

Modus:

Obligatory Course

Work Load

300 h

Credits

10 CP

Contact Time

100 h

Self-study

200 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

each winter term

Group Size

40

Duration

1 Semester

Learning results & Competences

Students know the basic toolbox of algorithm design and analysis. They can prove correctness of algorithms and analyze their running time and space requirements using O-Notation. They know the differences between basic complexity classes and can prove NP-completeness using reduction techniques. They know and can apply the major algorithmic design principles. They know algorithms for classic problems such as sorting, searching and pattern matching as well as important data structures for dictionaries and text indexing. They are able to work with graphs and understand and can apply and analyze classic graph algorithms.

On the practical side, students can work with the Unix shell, implement algorithms in Python and create data science workflows using Snakemake. Students can use a version control system (e.g. git) and docker to create reproducible execution environments. Students know how to test their code and are able to apply test driven development. Students can evaluate the quality of a given piece of code and provide feedback for improvement. Students are able to apply refactoring techniques in order to improve code quality. They are able to use a debugger to identify errors in code.

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

Algorithmic Problems. Algorithms and algorithmic problems, correctness proofs and running time analysis, O-Notation, computational complexity. The traveling salesman problem.

Programming and Software Engineering. Introduction to the Python programming language. Data science workflows with Snakemake. Version Control Systems, Creating reproducible execution environments, Software testing, Code Review, Code Quality, Refactoring, Debugging.

Algorithmic design principles. Brute force, recursion, divide-and-conquer, dynamic programming, branch-and-bound, greedy algorithms, heuristics. Approximation.

Classic algorithms and data structures. Quicksort/Mergesort/Heapsort, binary search, search trees, splay trees, B-trees, pattern matching, suffix trees, hashing.

Graph theory and graph algorithms. Graphs, topological sort, DFS/BFS, connectivity, shortest paths, minimum spanning trees

Exercises:

In the exercises the content of the lecture is applied and deepened in theoretical exercises. In addition, the students will implement selected algorithms and data structures in Python and will build algorithmic workflows using Snakemake. They will apply basic software engineering tools.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) Written examination about content of lectures

Prerequisites for receiving credit points

(1) Regular and active participation in the exercises

(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

German

English

German and English

German, English on demand

Further Information



Algorithmic Game Theory

Responsible for the Module:

Prof. Dr. Jörg Rothe

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Jörg Rothe

Semester:

variable

Modus:

Elective course

Work Load

300 h

Credits

10 CP

Contact Time

100 h

Self-study

200 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

–

Duration

1 Semester

Learning results & Competences

The goal of this module is to introduce into the most important topics, results, models, and methods of algorithmic game theory, which is a central theoretical foundation of numerous applications in artificial intelligence and multiagent systems. The students will get to know central game-theoretic problems and algorithms solving them; they will be able to modify and apply these algorithms; they learn how to describe strategic scenarios by cooperative or noncooperative games, and to formally characterize concepts of stability and equilibria in these games. They will also be able to analyse the corresponding decision and optimization problems (in suitable compact representations) in terms of their computational complexity.

Teaching

Lecture „Algorithmic Game Theory“: 4 SWS, Exercises: 2 SWS

Content

- Noncooperative Game Theory:
 - Foundations
 - o Normal form games, dominant strategies, and equilibria
 - o Two-person games
 - Nash equilibria in mixed strategies
 - o Definition and properties of mixed Nash equilibria
 - o Existence of Nash equilibria in mixed strategies
 - Checkmate: Trees for games with perfect information
 - o Sequential two-player games
 - o Equilibria in game trees
 - Full house: Games with incomplete information
 - o The Monty Hall problem
 - o Analysis of a simple poker variant
 - How hard is it to find a Nash equilibrium?
 - o Nash equilibria in zero-sum games
 - o Nash equilibria in general normal form games
- Cooperative Game Theory

- Foundations
 - o Cooperative games with transferable utility
 - o Superadditive games
 - o Stability concepts for cooperative games
- Simple games
 - o The core of a simple game
 - o Counting and representing simple games
 - o Weighted voting games
 - o Dimensionality
 - o Power indices
 - o The Shapley-Shubik index and the Shapley value
 - o The Banzhaf indices
- Complexity of problems for succinctly representable games
 - o Games on graphs
 - o Weighted voting games
 - o Hedonic games

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

- German
- English
- German and English
- German, English on demand

Further Information

Literature

- Jörg Rothe (ed.): Economics and Computation: An Introduction to Algorithmic Game Theory, Computational Social Choice, and Fair Division, Springer-Verlag, 2015.

A shorter German version of this book appeared as:

- Jörg Rothe, Dorothea Baumeister, Claudia Lindner und Irene Rothe: Einführung in Computational Social Choice. Individuelle Strategien und kollektive Entscheidungen beim Spielen, Wählen und Teilen, Spektrum Akademischer Verlag (Springer), 2011.

Additional literature

- Bezalel Peleg and Peter Sudhölter: Introduction to the Theory of Cooperative Games, Kluwer Academic Publishers, 2003.
- Martin J. Osborne and Ariel Rubinstein: A Course in Game Theory, MIT Press, 1994.
- Georgios Chalkiadakis, Edith Elkind, and Michael Wooldridge: Computational Aspects of Cooperative Game Theory, Morgan and Claypool Publishers, 2011.
- Noam Nisan, Tim Roughgarden, Eva Tardos, and Vijay V. Vazirani (eds.): Algorithmic Game Theory, Cambridge University Press, 2008.



Algorithms for Sequence Analysis

Responsible for the Module:

Prof. Dr. Tobias Marschall

Date:

24.06.2021

Lecturer(s)

Prof. Dr. Tobias Marschall

Semester:

variable

Modus:
Elective course**Work Load**

300 h

Credits

10 CP

Contact Time

100 h

Self-study

200 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

each summer term

Group Size

40

Duration

1 Semester

Learning results & Competences

This course enables students to understand advanced algorithmic concepts in sequence analysis and to apply them in practice. In particular, this course will provide the algorithmic foundation to develop modern tools to process DNA sequencing data. However, the focus is on general algorithmic concepts and hence the scope of applications is not limited to biological sequence analysis.

Teaching

Lecture with (theoretical and practical) exercises

Content

Sequence information is ubiquitous in many application domains –and collections strings are one important data type in modern Data Science. DNA sequencing data are one example that motivates this lecture, but the focus of this course is on algorithms and concepts that are not specific to bioinformatics. This lecture addresses classic as well as recent advanced algorithms for the analysis of large sequence databases. Topics include: full text search without index; approximate pattern matching; index structures such as suffix trees and enhanced suffix arrays, Burrows-Wheeler transform and the FM index; De Bruijn graphs; data compression; multiple sequence alignment; Positional Burrows-Wheeler Transform; and Locality Sensitive Hashing.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** Advanced Programming and Algorithms**Examination**

(1) usually oral exam

Prerequisites for receiving credit points

(1) Regular and active participation in the exercises: 50% of the programming exercises and 50% of the theoretical exercises need to be solved.

(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Informatik

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Causality

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

variable

Modus:

Elective Course

Work Load

150h

Credits

5 CP

Contact Time

64h

Self-study

86h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

yearly

Group Size

40

Duration

1 Semester

Learning results & Competences

After successfully finishing the course, the student

- * can understand and can explain the theoretical foundations of causal inference
- * can implement and apply algorithms of causal inference

Teaching

Lecture with theoretical and practical exercises

Content

This module teaches foundational knowledge about:

- * Directed acyclic graphs, causal graphs
- * Conditional independence
- * PC algorithm
- * Structural equation models
- * Additive noise models
- * Interventions
- * Counterfactuals
- * Markov equivalence
- * Faithfulness
- * Distinguishing cause and effect

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination**

(1) Written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

- German
- English
- German and English
- German, English on demand

Further InformationLiterature:

Main text book is:

* Peters/Janzing/Schölkopf, Elements of Causal inference, MIT

Additionally, the following books are helpful:

* Spirtes/Glymour/Scheines, Causation, Prediction, and Search, MIT 2000

* Pearl: Causality, Cambridge 2000



Computational Linguistics

Responsible for the Module:

Prof. Dr. Laura Kallmeyer (kallmeyer@phil.hhu.de)

Date:

17.05.2019

Lecturer(s)

the lecturers of the Department of Computational Linguistics, Prof. Dr. Stefan Conrad

Semester:

2. – 3.

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Seminar: 4 SWS

Turnus

yearly

Group size

–

Duration

1 Semester

Learning results & Competences

Students will understand the intricacies of modeling a specific linguistic phenomenon in such a way that it can be processed automatically. Furthermore, they will get to know different techniques

a) for learning such a model from language data,

b) for applying it to new data and

c) for evaluating it in order to assess its adequacy with respect to the phenomenon one wanted to model.

This can include frameworks and representation formats for modeling syntax (the structure of sentences and texts) and semantics (the meaning of sentences and text) and various machine learning and deep learning techniques applied to this.

Teaching

Advanced seminar (depending on the topic including practical exercises besides theoretical sessions)

It is possible to take two seminars of 2 SWS each instead of a single one of 4 SWS

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Inhaltlich: none

Examination

(1) Written examination or oral examination or term paper

Prerequisites for receiving credit points

(1) Passing examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

- Deutsch
- Englisch
- Deutsch und Englisch
- Deutsch, Englisch bei Bedarf

Further Information



Master Seminar Computational Multiomics

Responsible for the Module:

Prof. Dr. Tobias Marschall

Date:

24.06.2021

Lecturer(s)

Prof. Dr. Tobias Marschall

Semester:

variable

Modus:
Elective course**Work Load**

150 h

Credits

5 CP

Contact Time

50 h

Self-study

100 h

Course

Seminar: 2 SWS

Turnus

each winter term

Group Size

40

Duration

1 Semester

Learning results & Competences

Participants will be given an insight into high-throughput technologies and the kind of data gathered in such experiments. A key skill that is taught in this course is the art of transducing biological questions into computational problems that can be efficiently solved. Further, participants have the opportunity to increase their proficiency in the critical dissemination of scientific papers and giving oral presentations.

Teaching

Seminar talks.

Content

Modern laboratory equipment enables high-throughput experiments that provide detailed insights into molecular biology. These give rise to several branches of research including genomics, transcriptomics, proteomics, metabolomics, epigenomics, and metagenomics, with -omics meaning "the total of some sort". Omics experiments produce massive amounts of data that are subject of a variety of challenging computational problems. In this class, computational problems and their solutions for the analysis of multiomics experiments are presented and discussed. Participants will be assigned individual topics. The selection and matching between topics and participants will be determined in the first meeting of the seminar.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** Advanced Programming and Algorithms**Examination**

Graded seminar talk

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Informatik

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language German English German and English German, English on demand**Further Information**



Relational Databases and Data Analysis

Responsible for the Module:

Prof. Dr. Stefan Conrad (stefan.conrad@uni-duesseldorf.de)

Date:

17.04.2019

Lecturer(s)

Prof. Dr. Stefan Conrad

Semester:

3. – 4.

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS
Exercises: 2 SWS

Turnus

irregular

Group Size

–

Duration

1 Semester

Learning results & Competences

Relational Databases. Students understand the relational model for databases together with its foundations (e.g. relational algebra). They are able to design relational databases and to express simple and complex database queries using SQL.

Data warehouses. Students know the basic architecture and central concepts of data warehouses and can explain them. They can design relational data warehouses using multi-dimensional modelling.

OLAP and complex database queries.

Students are able to understand, analysis and formulate complex OLAP and database queries using the SQL query language and its OLAP extension.

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

- Introduction into the relational database model and relational data warehouses;
- Design of relational databases
- Multi-dimensional modelling for (relational) data warehouses
- SQL
- OLAP
- Complex OLAP queries in SQL for data analysis

Exercises:

In the exercises the content of the lecture is applied and deepened. For that the exercises contain theoretical as well as practical elements. In particular, the development of complex OLAP and database queries using the language SQL can practically be carried out using a database system provided to the students.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

- (1) Written examination or oral examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

German

English

German and English

German, English on demand

Further Information



Data & Knowledge Engineering (DKE)

Responsible for the Module:

Prof. Dr. Stefan Dietze

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Stefan Dietze

Semester:

2.-3.

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

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Duration

1 Semester

Learning results & Competences

- Application of W3C Standards (RDF, SPARQL) for using and extracting Knowledge Graphs, Linked Data and structured Data in the Web
- Basic understanding of Information- und Knowledge Extraction Methods
- Generation of formal Knowledge Representations and Knowledge Databases using Description Logics
- Understanding and applying structured Web Markup (RDFa, Microdata, schema.org)

Teaching

Lecture „Data & Knowledge Engineering“, 2 SWS (in English)

Excercise, 2 SWS (in English)

Content

Understanding and interpreting heterogeneous data, in particular in distributed settings such as the Web, remains a challenging task. State-of-the-art Web applications such as Web search engines rely on a combination of approaches for making sense of data, involving both explicit knowledge, for instance, through knowledge graphs such as Wikidata or the Google knowledge graph and semi-structured Web markup, as well as statistical and machine-learning based approaches.

This course provides an introduction to data and knowledge engineering methods and principles, with a particular focus on the Web. This includes methods related to knowledge graphs and formal data & knowledge representation (RDF, OWL, Description Logics), data integration and linking, information extraction, Web data sharing practices (Linked Data, Semantic Web and affiliated W3C standards such as RDF, RDFa, Microdata), as well as emerging approaches in the context of distributional semantics, such as word and entity embeddings. Attention will also be paid to applications of taught techniques to facilitate data sharing and reuse on the Web.

Prerequisites for attendingFormal: Admission to master studies in „Artificial Intelligence and Data Science“.Contentual: none

Examination

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

- German
 English
 German and English
 German, English on demand

Further InformationLiterature:

- “Artificial Intelligence: A Modern Approach” by Stuart Russell and Peter Norvig (2nd edition, Prentice-Hall, 2003)
- “A Semantic Web Primer” by Grigoris Antoniou and Frank van Harmelen (MIT Press, 2004)
- “Foundations of Semantic Web Technologies”, P. Hitzler, M. Krötzsch, S. Rudolph:, CRC Press, 2009.
- “Linked Data – Evolving the Web into a Global Data Space”, T. Heath, Ch. Bizer, Morgan & Claypool, 2011.
- Doing Data Science – Straight Talk from the Frontline, Cathy O’Neil, Rachel Schutt, O’Reilly Media



Deep Learning in Life Science: Generative Models

Responsible for the Module:

Prof. Dr. Markus Kollmann

Date:

01.05.2019

Lecturer(s)

Prof. Dr. Markus Kollmann

Semester:

2.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

50 h

Self-study

100 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

Summer Semester

Group Size

40

Duration

1 Semester

Learning results & Competences

Students know how to implement machine learning algorithms in Pytorch and to run it on HPC. They understand central concepts of Machine Learning and are familiar with common Neural Network architectures, based on convolutional and/or attention layers. They know how to implement Deep Generative Models such as Variational Autoencoder, Autoregressive Networks, Normalizing Flow based Networks, and Score based Generative Models. They understand the conceptual differences between the generative models, their advantages, and their shortcomings.

Teaching

Lecture with (theoretical and practical) exercises

Content*Lectures and Practical Work:*

We start with a brief introduction to common neural network structures, such as Convolutional Neural Networks in general and ResNets in particular and show how to implement and train them. We introduce different concepts of generative models and the training objectives behind them. We apply generative models to toy data sets and to the important problem of Protein/RNA folding.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** Decent understanding of Machine Learning**Examination**

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science, M.Sc. Biology, M.Sc Biochemistry

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- German
- English
- German and English
- German, English on demand

Further Information

Students from Biology and Biochemistry will be assigned 7CP for the course as it takes them significantly more time to carry out the programming exercises



Deep Learning in Life Science: Representation Learning

Responsible for the Module:

Prof. Dr. Markus Kollmann

Date:

01.05.2019

Lecturer(s)

Prof. Dr. Markus Kollmann

Semester:

2.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

50 h

Self-study

100 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

Winter Semester

Group Size

40

Duration

1 Semester

Learning results & Competences

Students know how to implement machine learning algorithms in Pytorch and to run it on HPC. They understand central concepts of Machine Learning and are familiar with common Neural Network architectures, such as Convolutional Neural Networks. They understand the difference between Maximum Likelihood Learning and Contrastive Learning. They are familiar with data augmentation methods and simple sampling methods.

Teaching

Lecture with (theoretical and practical) exercises

Content*Lectures and Practical Work:*

We start with a brief introduction to common neural network structures, such as Convolutional Neural Networks in general and ResNets in particular and show how to implement and train them. We show how to construct loss functions and how to find analytical expressions for the asymptotically optimal solutions, using Variational Calculus. We introduce Contrastive Learning -- and Self-supervised Learning in general -- as methods for Representation Learning. We introduce Autoencoders -- and Generative Models in general -- as methods for learning the data hyperplane. We discuss why including prior knowledge is the key for the success of Machine Learning Methods in diagnostic and therapeutic applications.

In the practical work we apply Representation Learning to detect heart arrhythmias from real time series data of patients and anomalies in (medical) image data.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** Decent understanding of Machine Learning**Examination**

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science, M.Sc. Biology, M.Sc Biochemistry

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- German
- English
- German and English
- German, English on demand

Further Information

Students from Biology and Biochemistry will be assigned 7CP for the course as it takes them significantly more time to carry out the programming exercises



Deep Learning

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

2./3.

Modus:

Obligatory Course

Work Load

150h

Credits

5 CP

Contact Time

60h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

yearly

Group Size

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Duration

1 Semester

Learning results & Competences

After successfully finishing the course, the student

- * can understand and can explain the theoretical foundations of deep learning
- * can implement and apply algorithms of deep learning

Teaching

Lecture with theoretical and practical exercises

Content

This module teaches foundational knowledge about:

- * Loss functions and optimization
- * Neural networks / backpropagation
- * Deep learning software
- * Convolutional neural networks
- * Generative models
- * Recurrent neural networks

Prerequisites for attendingFormal: Admission to master studies in „Artificial Intelligence and Data Science“.Contentual: none**Examination**

- (1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

German

English

German and English

German, English on demand

Further Information

No special text book is used, the following book is helpful:

* Goodfellow et al, "Deep learning", MIT



Lab Rotations

Responsible for the Module:

Prof. Dr. Markus Kollmann

Date:

01.11.2019

Supervisors

All group leaders offering Lab Rotations

Semester:

2./3.

Modus:

Obligatory course

Work Load

300 h

Credits

10 CP

Contact Time

60h

Self-study

240 h

Course

Practical Work

Turnus

each year

Group Size

NA

Duration

6 Weeks

Learning results & Competences

Students can work independently on a specific Data Science / AI project within a larger research group. They understand how the data they work on have been generated and preprocessed. They understand the goals of the research project and how the data analysis is connected to it. They are able to identify suitable algorithms to analyse the data and know their limitations. They can benchmark algorithms against each other and can carry out statistical analysis of their performance. They are able to present the results of their work to an audience that has different scientific background.

Procedure

Students can apply to research groups that generate/analyse data to carry out a lab rotation. The group leaders offering lab rotation places may choose among applicants according to their suitability. Lab rotations can also be carried out outside the university in R&D environments that generate/analyse sufficiently large data sets. The lab rotation requires permanent physical presence of the student within the chosen research group. The student is co-supervised by a member of the chosen research group and a lecturer that is involved in a theoretical module in the Master's Program „Artificial Intelligence and Data Science“.

Content

The co-supervisors agree on a lab rotation project based on the tasks to be carried out. The project can involve all steps of a data analysis pipeline – e.g. data cleaning, data preprocessing, data analysis, data postprocessing, data visualization – but not data generation. Ideally, these tasks should be realized by self-written code. Special emphasis in a lab rotation should be given to sensitise students for the peculiarities of the involved data and that students give understandable presentations of their results.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

None.

Prerequisites for receiving credit points

- (1) Permanent presence in the chosen research/development group
- (2) Active participation at research/development work
- (3) Giving a seminar talk

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

No

Weight in overall rating

None

Language

- German
- English
- German and English
- German, English on demand

Further Information



Markov Chains

Responsible for the Module: Prof. Dr. Peter Kern (kern@hhu.de)		Date: 01.04.2019	
Lecturer(s) Prof. Dr. Peter Kern, Prof. Dr. Axel Bücher		Semester: 2./3.	
Contact and organization Prof. Dr. Peter Kern (kern@hhu.de)		Modus: Elective Course	
Work Load 150 h	Credits 5 CP	Contact Time 45 h	Self-study 105 h
Course Lecture: 2 SWS Exercises: 1 SWS	Turnus Summer term, irregular	Group Size 20	Duration 1 semester

Learning results & Competences

The students overcome with the basic principles and the basic mathematical theory of Markov chains. They are able to argue on the basis of mathematical definitions and theorems to solve selected problems independently and to present their solution. They gain methods of systematic and efficient knowledge acquisition. The students will reach a deep understanding of basic techniques and convergence results for Markov models. They will be able to adapt algorithms based on Markov chains to data, to apply these and to discuss the results critically.

Teaching

Lecture with exercise course.

Content

Lecture

The first part of the lecture covers the basic mathematical theory of Markov chains: Markov property, random walk, transition matrices, transition graphs, Chapman-Kolmogorov equation, classification of states, irreducibility, periodicity, recurrence and transience, renewal equation, strong Markov property, equilibrium distribution, ergodic theorems. The second part of the lecture focusses on practical aspects of these methods: branching processes, time to absorption, Markov chain Monte Carlo (MCMC) method, Metropolis sampler, Gibbs sampler, Ising model, simulated annealing, cooling schedules.

Exercise course

The lectures are accompanied by weekly exercise courses in which exercises concerned with the practical applications of selected problems and with the aim of a deeper understanding of the mathematical theory of Markov chains are discussed. These problems are first solved by the students independently, and afterwards the corrected homework is presented and discussed in the exercise courses.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: Passed exam in „Mathematical and Statistical Foundations in Data Science“. It is further recommended to have taken a course on stochastics previous to this course.

Examination

Learning portfolio consisting of:

- (1) Competence area knowledge (100% of final mark): Written exam on the contents of lectures and exercise classes.
- (2) Application of acquired knowledge (40% of exercise points as admission to the final exam): Practical exercises during the semester.

Prerequisites for receiving credit points

- (1) Passing the exam.
- (2) Regular and active attendance to exercises.

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

B.Sc. Mathematik und Anwendungsgebiete, B.Sc. Finanz- und Versicherungsmathematik

Weight in overall rating

The mark will contribute to the final grade in relation to its credit points.

Language

- Deutsch
- English
- Deutsch und Englisch
- Deutsch, Englisch bei Bedarf

Further Information



Master Thesis

Responsible for the Module:

Prof. Dr. Markus Kollmann

Date:

01.11.2019

Supervisors

All group leaders offering projects for Master Thesis

Semester:

4th

Modus:

Obligatory course

Work Load

900 h

Credits

30 CP

Contact Time

60h

Self-study

840 h

Course

Practical Work

Turnus

NA

Group Size

NA

Duration

6 Month

Learning results & Competences

With the written thesis, the students prove that they are able to carry out scientific work independently on a topic in the field of Artificial Intelligence and Data Science within a given period of time (6 months). They are able to develop their findings concisely and to evaluate or interpret them competently. The Master's thesis must be written in English and presented in an oral presentation.

Procedure

Students can apply to any research group that offers data science projects for a Master Thesis. Ideally, the thesis should be carried out in one of the two groups where a Lab Rotations has been completed. If the Master Thesis is carried out outside the computer science department the student is co-supervised by a member of the chosen research group and a lecturer that is involved in a theoretical module in the Master Program „Artificial Intelligence and Data Science“.

Content

The content of the master thesis is defined by the supervisor.

Prerequisites for attending

Formal: Starting a Master Thesis requires at least 60CP of passed courses within the program „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) Grading of the content of Master Thesis and its oral presentation

Prerequisites for receiving credit points

- (1) Successful work on the topic and on-time submission of the thesis
- (2) Giving an oral presentation of the content of the thesis

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information

Neuroimaging and Precision Medicine



Responsible for the Module Prof. Dr. S. B. Eickhoff (S.Eickhoff@fz-juelich.de) Prof. Dr. S. Caspers (svenja.caspers@hhu.de) PD Dr. S. Weis (S.Weis@fz-juelich.de)	Date: 01.04.2019
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Lecturer(s) Prof. Dr. S. Eickhoff, Prof. Dr. C. Caspers, PD Dr. S. Weis	Semester: 3.
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	Modus: Elective Course
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Worl Load 150 h	Credits 5 CP	Contact Time 45 h	Self-study 105 h
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Course Vorlesung: 2 SWS Seminar: 1 SWS	Turnus Every Summer Term	Group Size 25	Duration 1 Semester
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Learning results & Competences

Neuroimaging

Students will be able to describe the basic principles of cognitive neuroimaging of the human brain as a basis for the subsequent application of Big Data and AI approaches. For all important imaging modalities, they can explain the relationship between neuronal activity and the measured signal. They will be able to evaluate strengths and weaknesses of the different modalities to address specific research questions. They will be able to explain the basics of experimental design and the statistical analysis of neuroimaging studies. In particular, they will be able to decide which approaches to the data analysis of brain imaging data are suitable for answering specific questions.

Precision Medicine

Students will have an understanding of how the collection and analysis of very large datasets (so-called "big data") can be used to study functional brain organization in the healthy brain and its disorders. They will understand how AI and data science can be used to draw conclusions about individual differences in the brain organization and identify biomarkers. Students will have an overview of clinical applications of the above methods for specific neurological and psychiatric disorders such as Parkinson's disease, Alzheimer's disease or schizophrenia.

Teaching

Lectures and Seminars

Content

Lectures

Lectures start with an introduction to the main methods of structural and functional neuroimaging. Students learn the necessary steps for pre-processing and statistical analysis of the data. The usual methods of data analysis, such as case studies, group studies and correlation analyses, are discussed to give students an insight into what conclusions can be drawn from the various types of analysis and which methodological approaches are suitable for addressing which questions. In the second part of the lectures methodical approaches for

the analysis of "Big Data" and for conclusions about individual differences in the structural and functional brain organization are discussed. In particular, prediction and classification analyses are presented using brain imaging data. The lecture also deals with applications and results of these methods in the clinical context as well as with studies on the identification of individual biomarkers.

Seminars

It is the aim of the seminars to familiarize students with current research questions in the field of AI / Data Sciences in the Neuroscience and in Precision Medicine, and to encourage critical reflection of such issues. To this end, a series of current research topics in these areas will be discussed in the form of presentations prepared by the students themselves. The possible subject areas are varied, and the individual interests of the students can be taken into account. To give a comprehensive overview of the topic, the articles will be suggested by the lecturers.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

Oral examination

Prerequisites for receiving credit points

- (1) Oral Presentation
- (2) Active presence in seminars

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

Englisch

Further Information

		Philosophy of Intelligence	
Responsible for the Module Prof. Dr. Gottfried Vosgerau (vosgerau@hhu.de)		Date: 01.03.2019	
Lecturer(s) Prof. Dr. Gottfried Vosgerau, Prof. Dr. Frank Dietrich, and further staff of the Institute of Philosophy		Semester: 2./3.	
Contact and organization Prof. Dr. Gottfried Vosgerau (vosgerau@hhu.de)		Modus: Elective Course	
Work Load 150 h	Credits 5 CP	Contact Time 60 h	Self-study 90 h
Course Übung: 2 SWS Vorlesung: 2 SWS	Turnus Every Summer term	Group Size 20	Duration 1 Semester
Learning results & Competences <p>Concepts and Measurements of Intelligence. Students are able to explain and criticize different conceptions of intelligence in Psychology and Philosophy. Students are able to connect the different conceptions to specific ways of measuring intelligence and to evaluate the theoretical soundness of the measurements in relation to the different conceptions.</p> <p>Cognitive Models of Intelligence. Students are able to explain the theoretical foundations of cognitive modelling and cognitive architecture. They are able to name the most important cognitive faculties and to describe functional interdependencies. They are able to explain and criticize representationalist and anti-representationalist conceptions of the mind.</p> <p>Goals and Limits of Cognitive Modelling. Students are able to describe the different possible goals of cognitive modelling within the cognitive sciences. They are able to identify the limits of different approaches in relation to the according epistemological goals.</p> <p>The Ethics of Artificial Intelligence. Students know the most important ethical questions arising in the context of developing and implementing AI systems. They are able to discuss these questions against the background of different ethical theories.</p>			
Teaching Vorlesung mit Lektüre-Übungen			
Content <u>Lectures</u> The lecture starts with an historical overview of the different conceptions of intelligence in Psychology and Philosophy. The theoretical basis of these conceptions is introduced along with the proposed measurement of intelligence. The students learn to criticize the different approaches on the basis of the theoretical conceptions and to name their limits. Then, the relation between theories in Cognitive Science and cognitive modelling is introduced and discussed. A focus will be set on connectionist models in contrast to classical symbol- and rule-based models. The discussion of the different models will especially highlight the different cognitive faculties that favor one or the other model of explanation. With concrete examples, the interdependency between the explanatory goals and the virtues and limits of cognitive modelling are introduced. Finally, a systematic overview of the most important ethical questions arising in the context of developing and implementing AI systems will be given. Based on prominent examples, different ethical theories are illustrated.			

Exercise

The exercise will consist in the critical reading and discussion of key texts pertinent to the topics of and in parallel with the lecture.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

Portfolio consisting of:

- (1) A written online-exam (80%) and
- (2) Skillful participation in the discussions of the exercise, which can be documented orally or in writing according to the choice of the exercise instructor (20%).

Prerequisites for receiving credit points

- (1) Passing grade in the exam and successful documentation of participation in the exercise

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs**Weight in overall rating**

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- Deutsch
 Englisch
 Deutsch und Englisch
 Deutsch, Englisch bei Bedarf

Further Information



Statistical Data Analysis

Responsible for the Module Prof. Dr. Holger Schwender (holger.schwender@hhu.de)		Date: 01.04.2019	
Lecturer(s) Prof. Dr. Holger Schwender, Prof. Dr. Axel Bücher		Semester: 2./3.	
Contact and organization Prof. Dr. Holger Schwender (holger.schwender@hhu.de)		Modus: Elective Course	
Work Load 150 h	Credits 5 CP	Contact Time 45 h	Self-study 105 h
Course Lecture: 2 SWS Exercises: 1 SWS	Turnus About every fourth semester	Group Size 20	Duration 1 Semester

Learning results & Competences

The students will be able to perform statistical analyses of different types of data and to use the statistical software environment and language R for these data analyses. The students will acquire knowledge on different types of statistical methods such as testing procedures, analysis of variance, and regression methods, on how to use these methods for a statistical data analysis, and on good practice in planning a study, in preparing data sets for a statistical analysis, as well as in presenting the results of a statistical analysis using, e.g., graphical data presentations. They will be able to decide which of the statistical methods to use in which situation and to apply these procedures to the data.

Teaching

Lecture with exercise course.

Content

Lecture

The lecture covers a wide range of statistical methods focusing on the practical aspects of these methods and their application to different types of data. Since the statistical software environment and language R is the most popular, advanced software for statistical analysis, R is mainly used in the lecture to exemplify the application of the statistical procedures. Therefore, the lecture starts with a basic, practical introduction to R. This knowledge on R is successively extended during the semester (in both the lectures and the exercise courses). It is discussed how graphics and descriptive statistics can be generated in R and should be generated in general to present and summarizing the data and the results of a data analysis in a best practice way. Moreover, good practice in preparing a data set for a statistical data analysis in, e.g., R is discussed. Prior to the actual data analysis an important step is the preprocessing of the data including checking the data for plausibility or errors, determining whether input variables should be transformed and how they could be transformed, as well as handling missing values in the data. Therefore, these issues will be discussed in the lecture in a practical way. Afterwards, the general principle of statistical testing and multiple statistical testing as well as testing procedures for the most important testing situations are taught. It is discussed how to apply these tests to data, how to check the assumptions of these tests, and how to select the most appropriate test for a particular testing situations. The rest of the course is dedicated to one- and multi-way analysis of variance as well as different regression methods including linear regression, generalized linear models (especially, logistic regression), regularized regression (e.g., ridge regression and Lasso), (generalized) linear

mixed models, Cox proportional hazard models, and nonparametric regression models (e.g., kernel smoothing, smoothing splines, or neural nets from a regression perspective). Besides the Cox regression, survival analysis is also considered in general. Again, in the discussion of the analysis of variance and the regression methods, emphasis will be placed on practical aspects of the application of these methods to data, considering different types of data sets.

Exercise course

The lectures are accompanied by exercise courses in which exercises concerned with the practical application of the statistical procedures taught in the lectures to data sets from different fields of application are discussed. These data analysis problems are solved by the students independently, and afterwards, presented and discussed in the exercise courses.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: Passed exam in „Mathematical and Statistical Foundations in Data Science“. It is recommended to have taken a course on stochastics previous to this course.

Examination

Typically, a written examination about the content of this course.

Prerequisites for receiving credit points

- (1) Passing the exam.
- (2) Regular and active attendance of the practicals.

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

B.Sc. Mathematics

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- Deutsch
 English
 Deutsch und Englisch
 Deutsch, Englisch bei Bedarf

Further Information



Statistical Learning

Responsible for the Module

Prof. Dr. Axel Bücher (axel.buecher@hhu.de)

Date:

20.06.2019

Lecturer(s)

Prof. Dr. Axel Bücher, Prof. Dr. Holger Schwender

Semester:

2./3.

Contact and organization

Prof. Dr. Axel Bücher

Modus:

Elective Course

Work load

150h

Credits

5 CP

Contact Time

45 h

Self-study

105 h

CourseLecture: 2 SWS
Exercise Course: 1 SWS**Turnus**

irregular

Group Size

20

Duration

1 Semester

Learning results & Competences

The students will acquire knowledge on different types of statistical learning methods, with an emphasis on dimensionality reduction, clustering and classification. They will be able to apply those methods independently to different types of data, to present their solution and to discuss the results critically. The students gain profound knowledge in using the statistical software environment and language R for the data analyses. They gain methods of systematic and efficient knowledge acquisition.

Teaching

Lecture with exercise course.

ContentLecture

The lecture covers some of the most important statistical learning methods, with an emphasis on dimensionality reduction, clustering and classification, as well as on the application to different types of data. The lecture serves as a complement to the module „Statistical Data Analysis“, but may be attended without any knowledge from that module.

The lecture starts by discussing the most common approaches to dimensionality reduction, in particular principal component analysis and factor analysis based on latent variable models. The second part covers clustering methods, in particular hierarchical clustering algorithms based on similarity and dissimilarity measures and k-means clustering. The third part covers basic supervised learning methods for classification: classical approaches like linear and quadratic discriminant analysis and logistic regression, K-nearest Neighbors, classification trees (CART algorithm, weakest link pruning), ensemble methods like bagging and random forests, support vector machines, as well as model evaluation based on cross-validation.

Throughout the course, the presented methods will be illustrated by exemplarily applications carried out within the statistical software environment and language R, the nowadays most popular software for advanced statistical analysis. The knowledge on R is successively extended during the semester (in both the lectures and the exercise courses).

Exercise course

The lectures are accompanied by exercise courses in which exercises concerned with the practical application of the statistical learning methods to data sets from different fields of application are discussed. These data analysis problems are solved by the students

independently, and are afterwards presented and discussed in the exercise courses.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: Passed exam in „Mathematical and Statistical Foundations in Data Science“. It is further recommended to have taken a course on stochastics previous to this course.

Examination

Typically, a written examination about the content of this course.

Prerequisites for receiving credit points

- (1) Passing the exam.
- (2) Regular and active attendance of the practical work.

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

B.Sc. Mathematics

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

Deutsch

English

Deutsch und Englisch

Deutsch, Englisch bei Bedarf

Further Information



Generative Models and Sampling Methods

Responsible for the Module:

Prof. Dr. Markus Kollmann

Date:

01.05.2019

Lecturer(s)

Prof. Dr. Markus Kollmann

Semester:

2./3.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

40

Duration

1 Semester

Learning results & Competences

Students know the basic concepts of deep generative models and manifold learning. They understand the concepts of Variational Autoencoders, Autoregressive Networks, and Generative Adversarial Networks and can point out their pros and cons. They can implement generative models in Tensorflow/Pytorch. They understand the concepts of sampling methods, such as importance sampling, MCMC sampling, Gibbs sampling, and can implement these concepts in Python. They understand how deep generative models can strongly improve sampling efficiency and understand the connection to reinforcement learning

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

Variational Autoencoders: Variational objectives, Posterior, Encoder, Decoder, Latent space models, manifold learning,

Autoregressive Models: autoregressive concept (PixelCNN, Transformer), exposure bias

Generative Adversarial Networks: Discriminators, Stability Problems, Progressive growing

GANs. Sampling Methods: (Hamilton) MCMC, Metropolis Hastings, Gibbs, Importance

Sampling, Monte Carlo Tree Search.

Exercises:

In the exercises the content of the lecture is applied and deepened in theoretical exercises. In addition, the students will implement the central concepts in Python and apply them to real and self-generated data.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs**Weight in overall rating**

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Information Theory

Responsible for the Module:

Dr. Peter Arndt

Date:

15.12.2020

Lecturer(s):

Dr. Peter Arndt

Semester:

2.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

CourseLecture: 2 SWS
Exercises: 2 SWS**Turnus**

irregular

Group Size

20

Duration

1 Semester

Learning results & Competences

In this module students get to know fundamental and advanced concepts of information theory, their relation to coding, data compression and signal transmission. They get a better understanding of randomness, as captured by the concepts of entropy, information loss and Kolmogorov complexity. They obtain a principled view on general assumptions and techniques in machine learning, like the information bottleneck. They know applications to statistics and machine learning.

Teaching

Lectures with exercises

Content

Entropy, conditional, joint and relative entropy, mutual information and their interrelations, Source Coding Theorem, characterizations of entropy and relative entropy, Renyi and Tsallis entropy, universal source coding, Kolmogorov complexity and connection to entropy, applications of Kolmogorov complexity, entropy of stochastic processes, channel capacity and Channel Coding Theorem, differential entropy, Gaussian channel, maximum entropy distributions, higher information theoretic invariants, applications.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** None.**Examination**

1 written or oral examination

Prerequisites for receiving credit points

- 1 Regular and active participation in the exercises
- 2 Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

B.Sc. Mathematik und Anwendungsgebiete

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

English

Further Information



Introduction to Logic Programming

Responsible for the Module:

Prof. Dr. Michael Leuschel (michael.leuschel@hhu.de)

Date:

10.4.2019

Lecturer(s)

Prof. Dr. Michael Leuschel (michael.leuschel@hhu.de)

Semester:

3.

Contact and organization

Prof. Dr. Michael Leuschel (michael.leuschel@hhu.de)

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

90 h

Self-study

60 h

Course

Praktika: 4 SWS

Lectures: 2 SWS

Turnus

Every winter term

Group Size

30

Duration

1 Semester

Learning results & Competences

To understand and be able to use the main concepts of propositional and predicate logic

To understand the logic programming paradigm and be able to use it for problem solving

To be able to write Prolog programs in a logical style

To be able to use informed search algorithms (A*) and develop AI algorithms for game playing (Minimax)

Content

An important part of this unit is devoted to the study of logic. The discipline of logic is concerned both with proving theorems and also with drawing inferences from existing knowledge. The unit covers basic programming concepts of logical systems, resolution logic and horn clauses. This logical development provides a foundation for introducing the main concepts of logic programming. The unit also includes a practical introduction to the main features of Prolog, the language which implements this style of programming. Theoretical and practical topics are interleaved, the course as a whole dividing roughly equally between logic and theory and practical programming. The course covers many AI topics such as informed search algorithms (A*), constraint satisfaction and game playing (Minimax, Alpha-Beta pruning).

Prerequisites for attendingFormal: Admission to master studies in „Artificial Intelligence and Data Science“.Contentual: Foundations of software development and programming**Examination**

(1) Written examination (80% of grade)

(2) Assessment of practical work (20% of grade)

Prerequisites for receiving credit points

(1) Successful participation at the practical work

(2) Passed written examination

Study Program

M.Sc. Data Science and AI

Modul accessible for other Study Programs

B.Sc. Informatik

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

German

English

German and English

German, English on demand

Further Information



Machine Learning

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

1.

Modus:

Obligatory Course

Work Load

300 h

Credits

10 CP

Contact Time

100 h

Self-study

200 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

each winter term

Group Size

40

Duration

1 Semester

Learning results & Competences

After successfully finishing the course, the student

- * can understand and can explain the theoretical foundations of machine learning.
- * can explain the foundations in mathematical terms and can do proofs about it
- * can implement and apply algorithms of machine learning

Teaching

Lecture with theoretical and practical exercises

Content

This module teaches foundational knowledge about the following topics:

- * Probability, frequentist statistics, Bayesian statistics
- * Supervised learning, unsupervised learning
- * Generative vs discriminative models
- * Linear regression, linear discriminant analysis
- * Gaussian processes
- * Support vector machines
- * Kernel trick, kernel PCA
- * Graphical models
- * Neural networks

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination**

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

B.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information

No special text book is used, the following books are helpful:

- * Murphy, Machine Learning: A Probabilistic Perspective
- * MacKay, Information Theory, Inference, and Learning Algorithms, Cambridge 2003
- * Barber, Bayesian Reasoning and Machine Learning, Cambridge 2012
- * Rasmussen/Williams, Gaussian Processes for Machine Learning, MIT 2006
- * Bishop, Pattern Recognition and Machine Learning, Springer 2007
- * Schölkopf/Smola, Learning with Kernels, MIT 2001
- * Jaynes, Probability Theory – the Logic of Science, Cambridge 2003



Master Seminar Advances in Data Science

Responsible for the Module:

Prof. Dr. Stefan Dietze

Date:

01.05.2019

Lecturer(s)

Prof. Dr. Stefan Dietze

Semester:

2./3.

Modus:

Elective Course

Work Load

60 h

Credits

5 CP

Contact Time

30 h

Self-study

30 h

Course

Seminar: 2 SWS

Turnus

not regular

Group Size

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Duration

1 Semester

Learning results & Competences

Students have in depth understanding about actual methods and their applications in Data Science.

Teaching

Seminar „Advances in Data Science“

Content

Learning from data in order to gain useful insights is an important task, generally covered under the data science umbrella. This involves a wide variety of fields such as statistics, artificial intelligence, effective visualization, as well as efficient (big) data engineering, processing and storage, where efficiency and scalability often play crucial roles in order to cater for the quantity and heterogeneity of data.

The goal of this seminar is to deepen the understanding about data science & engineering techniques through studying and critically evaluating state-of-the-art literature in the field. Participants will be introduced to the critical assessment and discussion of recent scientific developments, thereby learning about emerging technologies as well as gaining the ability to evaluate and discuss focused scientific works. Participants will be given recent literature covering relevant data science areas. Each participant will review independently 1-2 publications and present and discuss its content and contribution, which are then presented and discussed with the entire student participants.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

Assessment of presentation

Prerequisites for receiving credit points

Active presence in seminar

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further InformationLiterature:

- R for Data Science (by Garrett Grolemund and Hadley Wickham) O'Reilly Media
- Statistics in a Nutshell, 2nd Edition, A Desktop Quick Reference, Sarah Boslaugh, O'Reilly Media
- Doing Data Science – Straight Talk from the Frontline, Cathy O'Neil, Rachel Schutt, O'Reilly Media
- Data Analytics with Hadoop, Benjamin Bengfort & Jenny Kim, O'Reilly Media
- Deep Learning by Ian Goodfellow and Yoshua Bengio and Aaron Courville
<http://www.deeplearningbook.org/>



Mathematical and Statistical Foundations of Data Science

Responsible for the Module:

Dr. Peter Arndt

Date:

01.05.2019

Lecturer(s)

Dr. Peter Arndt

Semester:

1.

Modus:

Obligatory course

Work Load

300 h

Credits

10 CP

Contact Time

100 h

Self-study

200 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

each winter term

Group Size

40

Duration

1 Semester

Learning results & Competences

Students know the basic concepts of linear algebra, convex optimization, Bayesian statistics, and information theory. They know the principles behind matrix differential calculus. They understand the difference between likelihood and posterior probability and can apply these concepts to solve (generalized) linear regression problems. They can apply Gaussian process priors to regression problems. They are familiar with regularization techniques to control overfitting. They know convex optimization problems and understand the techniques to solve them efficiently.

The students are familiar with the basic concepts of information theory. They understand the concept of discrete stochastic processes and their applications to sequential data. They know the concept of continuous time stochastic process. They are familiar with sampling methods and their application to Bayesian statistics.

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

Linear Algebra. Eigenvalue problems, Singular value decomposition, Low rank approximation, matrix differential calculus.

Regression. Linear models, generalized linear models, regularization.

Stochastic Processes. Markov property, Markov chains, state space models.

Convex Optimisation. Primal-dual-problem, Lagrangian, duality gap, KKT conditions, regularizing conditions.

Bayesian Statistics. A priori and a posteriori distributions, conjugate priors, Gaussian Process regression/classification, importance sampling rejection sampling, Markov Chain Monte Carlo, Metropolis Hastings, Gibbs sampling.

Information Theory. Jensen's inequality, Entropy, KL-divergence, Rate distortion theory, differential entropy, minimum description length.

Exercises:

The content of the lecture is applied and deepened in theoretical exercises. In addition, the students will implement the central concepts in Python and apply them to real and self-generated data.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) written examination

Prerequisites for receiving credit points

(1) Regular and active participation in the exercises

(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs**Weight in overall rating**

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Natural Language Processing

Responsible for the Module:

Prof. Dr. Stefan Conrad (stefan.conrad@uni-duesseldorf.de)

Date:

17.04.2019

Lecturer(s)

Prof. Dr. Stefan Conrad

Semester:

2./3.

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

CourseLecture: 2 SWS
Exercises: 2 SWS**Turnus**

irregular

Group Size

–

Duration

1 Semester

Learning results & Competences

Natural Language Processing (NLP). Students understand basic methods and algorithms for NLP and can explain them. They are able to design a NLP pipeline for a dedicated task and to implement it using adequate libraries. The students know how to evaluate NLP algorithms and whole pipelines and are able to interpret the results of such evaluations.

Information Retrieval. Students know basic retrieval models and information retrieval concepts and can explain them in the context of natural language processing.

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

- Introduction into Natural Language Processing (NLP) and Information Retrieval (IR) concepts
- NLP pipeline and basic NLP methods/algorithms
- Evaluation principles and measurements
- Selected applications for NLP

Exercises:

In the exercises the content of the lecture is applied and deepened. For that the exercises contain theoretical as well as practical elements. In particular, the development of NLP algorithms and the design of NLP pipelines can be practically carried out.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination:**

(1) Written or oral examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- Deutsch
- Englisch
- Deutsch und Englisch
- Deutsch, Englisch bei Bedarf

Further Information



Numerical Methods for Data Science

Responsible for the Module:

Prof. Dr. Christiane Helzel (christiane.helzel@hhu.de)

Date:

01.05.2019

Lecturer(s)

Prof. Dr. Christiane Helzel

Semester:

2./3.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

45 h

Self-study

105 h

Course

Lecture: 2 SWS

Exercises: 1 SWS

Turnus

irregular

Group Size

20

Duration

1 Semester

Learning results & Competences

The students will acquire knowledge on different numerical methods that are used to compute the solution of linear systems, least square problems, eigenvalue problems and the singular value decomposition. They will learn which algorithms are used in various situations.

Teaching

Lecture with (theoretical and practical) exercises

ContentLecture:

The class covers several powerful numerical linear algebra techniques that are used in various applications in data mining and pattern recognition. We first review basic linear algebra concepts and matrix decompositions, in particular the LU and the QR decomposition and use these techniques to solve linear systems and least square problems. Furthermore, we study different algorithms for computing eigenvalues and the singular value decomposition. Finally we will see how these concepts are used in different applications such as text mining, page ranking and face recognition. Throughout the course, the presented methods will be illustrated by test problems that are carried out in Matlab or Python.

Exercises:

The lectures are accompanied by exercise courses in which the students apply the different numerical methods that are covered in the lectures. Exercise problems are solved by the students independently, and are afterwards presented and discussed in the exercise courses.

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination**

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

B.Sc. Mathematics

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- German
- English
- German and English
- German, English on demand

Further Information**Literature:**

J.W.Demmel, Applied Numerical Linear Algebra, SIAM

L.Elden, Matrix Methods in Data Mining and Pattern Recognition, SIAM



Introduction to Linear Optimization

Responsible for the Module:

Prof. Dr. Gunnar Klau (gunnar.klau@hhu.de)

Date:

1.05.2019

Lecturer(s)

Prof. Dr. Gunnar Klau

Semester:

2./3.

Modus:**Elective Course****Work Load**

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

–

Duration

1 Semester

Learning results & Competences

Foundations of Linear Programming. Students know the definitions of linear programs (LPs), and their standard forms. They can solve low-dimensional LPs geometrically. They understand and can apply the Simplex method and the fundamental theorem of Linear Programming. They understand and can apply the concept and proofs of weak and strong duality.

Integer Linear Programming. Students know the definition of integer linear programs (ILPs) and the fundamental difference to LPs in terms of computational complexity. They understand the relation to combinatorial optimization problems. They know and can apply different methods to solve ILPs: Branch-and-Bound based on the LP relaxation, cutting planes, Branch-and-Cut and Lagrangian relaxation. They understand the concept of separation.

Network Flows. Students understand the concepts of networks and flows in networks. They can distinguish different variants and special cases of flow problems. They can compute maximum flows with the augmented path method (Ford-Fulkerson) and can prove why the method works. They understand the relation to duality in form of the max-flow-min-cut theorem.

Applications. Students can apply different modeling techniques to develop ILP formulations for combinatorial optimization problems. Examples include maximum clique, phylogeny reconstruction and the traveling salesman problem. They can solve real-world instances of these problems with self-written Python code using external optimization libraries.

Teaching

Lecture with theoretical and practical exercises

ContentLecture:

Foundations of Linear Programming. Linear Programs and their geometric interpretation. Duality. The Simplex method.

Integer Linear Programming. Linear programming-based Branch-and-Bound. Cutting planes. Branch-and-Cut. Lagrange relaxation.

Network Flows. Theory and algorithms.

Applications. Selected applications of linear optimization techniques from bioinformatics and other fields.

Exercises:

In the exercises the content of the lecture is applied and deepened. For that the exercises contain theoretical as well as practical elements. The students use professional linear and integer linear programming modeling software and solvers to build solve applied programming exercises.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: none

Examination

(1) written examination or oral examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Program

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- Deutsch
- Englisch
- Deutsch und Englisch
- Deutsch, Englisch bei Bedarf

Further Information



Reinforcement Learning

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

17.06.2019

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

2./3.

Modus:

Elective Course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

--

Duration

1 Semester

Learning results & Competences

After successfully finishing the course, the student

* can understand and can explain the theoretical foundations of reinforcement learning.

* can implement and apply algorithms of reinforcement learning.

Teaching

Lecture with theoretical and practical exercises

Content

- * The reinforcement learning problem
- * Multi-armed bandits
- * Markov Decision processes
- * Dynamic programming
- * Monte Carlo Methods
- * Temporal-difference learning
- * On- and off-policy methods
- * Eligibility traces
- * Policy gradients

Prerequisites for attendingFormal: Admission to master studies in „Artificial Intelligence and Data Science“.Contentual: none**Examination**

(1) written examination

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises?
- (2) Passing the examination?

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

- German
 English
 German and English
 German, English on demand

Further Information

Literature

Richard Sutton, Andrew Barto, "Reinforcement Learning: An Introduction", 2018, MIT press, draft online available



Master Seminar Advanced Mathematical and Numerical Methods in Data Science

Responsible for the Module:

Dr. Marcel Schweitzer

Date:

03.10.2020

Lecturer(s)

Dr. Marcel Schweitzer

Semester:

2./3.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

30 h

Self-study

120 h

Course

Seminar: 2 SWS

Turnus

irregular

Group Size

20

Duration

1 Semester

Learning results & Competences

Students acquire knowledge about state of the art numerical algorithms at the core of data science methods, or about advanced mathematical concepts and models used to structure or analyze data.

Teaching

Seminar

Content

Efficient numerical algorithms are an important ingredient of almost all applications in machine learning and data science. However, these algorithms are often more or less invisible to the user as they lie at the very core of data science methods. This seminar focuses on these algorithms and how they enable and improve methods in various applications across machine learning and data science. Another possible direction of this seminar is the discussion of advanced mathematical concepts that are aimed directly at structuring data or revealing structure within data.

Possible topics for the seminar:

- Interpretable matrix decomposition methods in data science
- Numerical linear algebra for second-order methods in deep learning
- Randomized numerical algorithms
- Tensor representations for high-dimensional data
- Mathematical analysis of complex networks

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination**

Graded seminar talk

Prerequisites for receiving credit points

Presence and active participation in the seminar

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs**Weight in overall rating**

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Master's Seminar on Information Theory, Inference, and Learning Algorithms

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

01.10.2020

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

2-3

Modus:

elective course

Work Load

60 h

Credits

5 CP

Contact Time**30 h****Self-study**

30 h

Course

Seminar: 2 SWS

Turnus

irregular

Group Size

Limited to 24

Duration

1 Semester

Learning results & Competences

After completion students have in-depth understanding of various methods and techniques from the areas of Information Theory, Inference and Learning Algorithms. They improve their presentational skills and understanding of the covered topics.

Teaching

Seminar „Information Theory, Inference, and Learning Algorithms“

Content

The Seminar aims to build upon and enhance the understanding of the lecture „Machine Learning“. Students will independently review and prepare 1-2 chapters from the Book „Information Theory, Inference, and Learning Algorithms“ by David MacKay, or other books or scientific publications related to the topic. Each week, 1-2 of the participants of the seminar will give a presentation, followed by a discussion involving all participants, focussing on content as well as the delivery of a good scientific presentation. In addition, each presenter is required to hand in a short summary of their presentation afterwards.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: Lecture „Machine Learning“

Examination

Assessment of the presentation

Prerequisites for receiving credit points

- (1) Active presence in the seminar
- (2) Presentation of a topic
- (3) Active participation in discussions
- (4) Written summary of the topic

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

English

Further Information

Literature:

Including David J.C.MacKay, „Information Theory, Inference, and Learning Algorithms“, Cambridge, PDF freely available on the author’s website.



Master's Seminar on Machine Learning

Responsible for the Module:

Prof. Dr. Stefan Harmeling

Date:

01.10.2020

Lecturer(s)

Prof. Dr. Stefan Harmeling

Semester:

2-3

Modus:

elective course

Work Load

60 h

Credits

5 CP

Contact Time**30 h****Self-study**

30 h

Course

Seminar: 2 SWS

Turnus

irregular

Group Size

Limited to 24

Duration

1 Semester

Learning results & Competences

After completion students have in-depth understanding of various methods and typical applications from the area of Machine Learning. They can independently review and evaluate scientific publications and improve their presentational skills.

Teaching

Seminar „Master's Seminar on Machine Learning“

Content

Machine Learning has gained large influence in many scientific areas and branches as a method of detecting patterns and structure in data and deriving decisions and predictions from those. In particular the ever-growing masses of data in companies, research and the internet has led to a broad demand for experts in this field. Because of the quick evolution and discovery of new methods, a constant occupation with the newest findings is necessary. This seminar aims to build upon and enhance the learnings from the lecture „Machine Learning“ by independent study of such scientific publications. Each week, 1-2 of the participants of the seminar will give a presentation, followed by a discussion involving all participants, focussing on content as well as the delivery of a good scientific presentation. In addition, each presenter is required to hand in a short summary of their presentation afterwards.

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“.

Contentual: Lecture „Machine Learning“

Examination

Assessment of the presentation

Prerequisites for receiving credit points

- (1) Active presence in the seminar
- (2) Presentation of a topic
- (3) Active participation in discussions
- (4) Written summary of the topic

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

English

Further Information



Spectral Graph Theory and Graph Signal Processing

Responsible for the Module:

Dr. Peter Arndt

Date:

03.10.2020

Lecturer(s)

Dr. Peter Arndt

Semester:

2./3.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

60 h

Self-study

90 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

20

Duration

1 Semester

Learning results & Competences

In this module, students learn about different matrix representations of graphs and how the eigenvalues and eigenvectors of those matrices reveal combinatorial properties of the graph and subsequently help analyzing and structuring the underlying data. Additionally it is discussed how concepts from classical signal processing (like convolution and the Fourier transform) can be adapted to signals on graphs. After covering these basic concepts, the main focus is on applying them to real-world complex networks from various application areas.

Teaching

Lecture with (theoretical and practical) exercises

ContentClassical spectral graph theory:

- Adjacency matrices
- The graph Laplacian
- Algebraic connectivity and the Fiedler vector
- The Cheeger constant and Cheeger's inequality
- Spectral clustering
- Graph coloring, the chromatic number and Wilf's theorem
- Centrality measures based on spectral information

Graph Signal processing:

- Signals on graphs
- Frequencies on graphs and the graph Fourier transform
- Interpreting graph frequencies
- Shifts and convolutions on graphs
- Total variation on graphs
- Diffusion processes on graphs
- Learning graphs from data

Applications:

- Community detection in complex networks
- Spreading of infectious diseases
- Efficient exploration of large networks
- Finding consensus in multi-agent systems via network dynamics
- Fake image detection with Forensic Similarity Graphs

Prerequisites for attending

Formal: Admission to master studies in „Artificial Intelligence and Data Science“

Contentual: Advanced Programming and Algorithms

Examination

(1) Written examination or oral examination

Prerequisites for receiving credit points

(1) Regular and active participation in the exercises

(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Modul accessible for other Study Programs**Weight in overall rating**

The mark given will contribute to the final grade in proper relation to its credit points.

Language

German

English

German and English

German, English on demand

Further Information



Spoken Dialogue Systems

Responsible for the Module:

Prof. Dr Milica Gasic

Date:

25.06.2019

Lecturer(s)

Prof. Dr Milica Gasic

Semester:

2./3.

Modus:

Elective Course

Work Load

300 h

Credits

10 CP

Contact Time

120 h

Self-study

180 h

Course

Lecture: 4 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

40

Duration

1 Semester

Learning results & Competences

On completion of this module, students should understand:

The purpose and operation of the main components of a spoken dialogue system

How the framework of partially observable Markov decision processes can be used to model a spoken dialogue system

How classification, regression, sequence-to-sequence models and reinforcement learning can be used to implement a spoken dialogue system. The various options for optimizing and adapting a statistical spoken dialogue system, both off-line and on-line, and how deep learning can be utilised to achieve state of the art results in dialogue modelling.

Teaching

Lecture with (theoretical and practical) exercises

Content

Introduction: architecture of a spoken dialogue system, dialogue acts, turn management issues

Semantic decoding: representing and decoding meaning from user inputs, semantic decoding as a classification task, semantic decoding as a sequence-to-sequence learning task

Dialogue state tracking: tracking beliefs over multiple turns, classical generative and discriminative approaches, recent deep learning approaches, integration of decoding and tracking.

Dialogue Management: modelling via Markov Decision Processes, reinforcement learning, gradient methods, Gaussian Processes

Response Generation: template methods, generative models, recent neural network approaches

Current research topics: incremental dialogue, towards open-domain systems, end-to-end neural network architectures

Practical Work:

Students will be provided with a set of Python tools which will enable them to configure and test a simple spoken dialogue system. They will be asked to implement a simple dialogue state tracker and a reinforcement learning algorithm and optimize the dialogue manager in interaction with a simulated user. This will give them an opportunity to explore a practical example of reinforcement learning.

Prerequisites for attending

Formal: none
Contentual: none

Examination

Assessment:
Written report of 2000 words covering the practical [100%]

Prerequisites for receiving credit points

- (1) Regular and active participation in the exercises
- (2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

M.Sc. Computer Science

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points

Language

German
English
German and English
German, English on demand

Further Information

Recommended Reading Page:

S. Young (2013). "Talking to Machines" Royal Academy of Engineering Ingenia, 54:40-46
S. Young, M. Gasic, B. Thomson and J. Williams (2013). "POMDP-based Statistical Spoken Dialogue Systems: a Review." Proc IEEE, 101(5):1160-1179



Topological Data Analysis

Responsible for the Module:

Prof. Dr. Marcus Zibrowius, Dr. Peter Arndt

Date:

14.10.2020

Lecturer(s)

Prof. Dr. Marcus Zibrowius, Dr. Peter Arndt

Semester:

2.

Modus:

Elective course

Work Load

150 h

Credits

5 CP

Contact Time

64 h

Self-study

86 h

Course

Lecture: 2 SWS

Exercises: 2 SWS

Turnus

irregular

Group Size

40

Duration

1 Semester

Learning results & Competences

The students know the general idea of algebraic topology and the notions of metric spaces, simplicial complexes, homotopy and (co)homology. They know how a point cloud gives rise to a filtered simplicial complex, via the Cech complex and the Vietoris-Rips complex constructions. They know the concept of persistent homology of a filtered simplicial complex. They know the mapper algorithm. They know software tools to perform topological data analysis in practice.

Teaching

Lecture with theoretical and practical exercises

Content

Simplicial complexes, triangulability, Simplicial homology, Cech complex & Vietoris-Rips complex, Decomposition of persistence modules, Barcodes & persistence diagrams, Persistent images, persistence landscapes and other approaches to feed persistence into machine learning, mapper algorithm, practical topological data analysis

Prerequisites for attending**Formal:** Admission to master studies in „Artificial Intelligence and Data Science“.**Contentual:** none**Examination**

(1) written or oral examination

Prerequisites for receiving credit points

(1) Regular and active participation in the exercises

(2) Passing the examination

Study Program

M.Sc. Artificial Intelligence and Data Science

Module accessible for other Study Programs

B.Sc. Mathematik und Anwendungsgebiete

Weight in overall rating

The mark given will contribute to the final grade in proper relation to its credit points.

Language

English

Further Information