Description of the degree program

Data Science (Master)
PO 1

Date: 27.03.2024

Table of contents

ECTS	120

Ramp Up Phase	
ECTS	10

Title	Ramp up Course Mathematics		
Number	1294580	**Module version**	V2
Shorttext		**Language**	
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	
Workload (h)			
Class attendance (h)	72	**Self studying (h)**	228
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 ungraded examination (Prüfungsleistung): 1 written exam (120 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement			
Module grade composition			

Contents

- Introduction to Data Science (2 weeks) - jointly with RampUp Computer Science
- Algebra (2 weeks)
- Numerics (2 weeks)
- Discrete mathematics (2 weeks)
- Analysis (2 weeks)
- Stochastics (2 weeks)
- Continuous optimization (2 weeks)

Objective qualification

The students
- know understand the underlying concepts of mathematics that are necessary for data science
- understand the concepts of analysis, algebra, optimization, discrete mathematics, stochastics and numerics and are able apply them in the context of data science

Literature

- Mathematics for machine learning, Deisenroth, Faisal, Ong, Cambridge University Press, available at https://mml-book.com/

- Networks, Crowds, and Markets: Reasoning about a Highly Connected World, Easley, Kleinberg, Cambridhe University Press, availale at https://www.cs.cornell.edu/home/kleinber/networks-book/networks-book.pdf

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Ramp Up Phase			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Ramp up Course Mathematics				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Matthias Bollhöfer Timo de Wolff Christian Kirches Jens-Peter Kreiß Dirk Lorenz Sebastian Stiller	Christian Kirches Christian Kirches	6	Lecture/Exercise	english
Literature				
(de/en) • Mathematics for machine learning, Deisenroth, Faisal, Ong, Cambridge University Press, available at https://mml-book.com/ • Networks, Crowds, and Markets: Reasoning about a Highly Connected World, Easley, Kleinberg, Cambridhe University Press, availale at https://www.cs.cornell.edu/home/kleinber/networks-book/networks-book.pdf				

Title	Ramp up Course Computer Science		
Number	4298040	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Wolf-Tilo Balke
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Ungraded examination (Prüfungsleistung): 1 written exam (120 min.), oral exam (30 minutes) or Take-Home-Exam		
Course achievement			
Module grade composition			

Contents

- Introduction to Data Science (2 weeks) - jointly with RampUp Mathematics
- Software engineering (Schulze, 4 weeks)
- Database management (Balke, 4 weeks)
- Security and privacy (Rieck, 2 weeks)
- Distributed systems (N.N., 2 weeks)

Objective qualification

After successful completion of this module, students have a basic understanding of the underlying concepts of computer science that are necessary for data science. They are able to
- design and develop software systems for data analysis
- understand and implement distributed analysis processes
- apply and operate modern database systems
- evaluate and protect the security and privacy of data

Further, students have a general overview of the methods of data science and the application areas. They know the general principles and processes of data science projects.

Literature

tba

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Ramp Up Phase			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Ramp up course Computer Science				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke Florian Plötzky Tobias Runge Sandro Schulze		6	Lecture/Exercise	english

Methods and concepts of Computer Science	
ECTS	25

Title	Pattern Recognition		
Number	2424690	**Module version**	
Shorttext	ET-NT-69	**Language**	english german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Oral exam 30 min. or written exam 90 min.		
Course achievement			
Module grade composition			

Contents

- Bayesian decision rule
- Quality metrics in pattern recognition
- Supervised learning with parametric distributions
- Supervised learning with non-parametric distributions, classification
- Linear discriminant functions, single-layer perceptron
- Support vector machines (SVMs)
- Multi-layer perceptron, neural networks (NNs)
- Deep learning
- Unsupervised learning, clustering methods

Note: For pattern recognition using hidden Markov models (HMMs), a separate more in-depth module, Spoken Language Processing (ET-NT-68), is offered in the summer semester.

Objective qualification

Upon completion of this module, students gain fundamental knowledge about methods and algorithms for classification of data. They are capable to select the appropriate means for real-world problems, to design a solution and to evaluate it.

Literature

- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001
- C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006

Remark

Basic knowledge of statistics, such as acquired in the module "Probability Theory and Statistics", facilitates the understanding of the lecture.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Björn Möller Ziyi Xu		2	Lecture	english
Literature				
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Björn Möller Ziyi Xu		2	Seminar	german
Literature				
- Vorlesungsfolien - R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006				

Title	Deep Learning Lab		
Number	2424750	**Module version**	
Shorttext	ET-NT-75	**Language**	english german
Frequency of offer	only in summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents
Objective qualification
Literature
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jasmin Breitenstein Tim Fingscheidt Marvin Klingner		3	Internship	german
Literature				
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jasmin Breitenstein Tim Fingscheidt Marvin Klingner		1	Colloquium	german
Literature				
- R.O. Duda, P.E. Hart, D.G. Stork: Pattern Classification, Wiley, 2001 - C.M. Bishop: Pattern Recognition and Machine Learning, Springer, 2006 - I. Goodfellow, Y. Bengio, A. Courville: Deep Learning, MIT Press, 2016				

Title	Replication and Consistency		
Number	4212620	**Module version**	V2
Shorttext	INF-THI-62	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Roland Meyer
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 written exam, 90 minutes or oral exam, 30 minutes or Take-Home-Exam		
Course achievement	50% of exercises must be passed		
Module grade composition			

Contents

- Hardware consistency models and programming idioms.
- Store atomicity, out-of-thin-air.
- CAT.
- C++11 atomics.
- Concurrent data structures.
- Pessimistic and optimistic concurrency.
- Linearizability and observational equivalence.
- Distributed systems and CAP.
- Transactions and ACID.
- Causal consistency, serializability, snapshot isolation.
- Eventual consistency and CRDTs.
- Conflict resolution.

Objective qualification

After successful completion of this module, students will
have a basic understanding of data replication strategies, consistency notions, and the corresponding programming methods. We cover all levels of abstraction, from hardware consistency models to geo-replicated databases. Confronted with an application, students will be able to develop and implement a suitable data replication scheme and argue for its correctness.

Literature

tba

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Roland Meyer		4	Lecture/Exercise	english german

Title	Knowledge based systems and deductive database systems		
Number	4214620	**Module version**	V2
Shorttext	INF-IS-62	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Wolf-Tilo Balke
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 written exam (90 minutes) or oral exam (30 minutes)		
Course achievement	50% of the exercises must be passed		
Module grade composition			

Contents

This module will give a broad overview over all methods and approaches that are necessary for reasoning over large knowledge bases using first order predicate logics. Moreover, the architecture of the Semantic Web is investigated with the a special focus on Semantic Web standards, modeling languages, ontologies and ontology languages, and advanced Semantic Web techniques. In particular,
- Logic programming, predicate logic as a data model
- Top-down and bottom-up strategies for query processing
- Datalog and processing recursive Datalog queries
- Query optimization with Magic Sets
- Knowledge representation
- Object-oriented extension, path queries
- Recursion in databases, Common Table Expressions
- User-Defined Types and User-Defined Functions
- Semantic Web standards (RDF, OWL, etc.)
- Semantic Web architecture and techniques

Objective qualification

On completion of this module, students are aware of the challenges and problems which arise from reasoning processes over large knowledge bases. This covers technical aspects (algorithms,implementations, etc.) and also methodological aspects (e.g. uncertainty, etc.). Furthermore, the students will be able to discuss the strengths and weaknesses of different approaches to reasoning and will be able to competently propose solution strategies to practical problem scenarios.

Literature

- S. Ceri, G. Gottlob, L. Tanca: Logic Programming and
Databases - Surveys in Computer Science. Springer Verlag,
1990.

- S.K. Das: Deductive Databases and Logic Programming. Addison-Wesley, 1992.

- J. Ullman: Principles of Databaseand Knowledge-Base Systems,Volume II: The New Technologies. W.H. Freeman & Co., 1989.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke		3	Lecture/Exercise	german

Title	Warehousing and Data Mining Techniques		
Number	4214680	**Module version**	V2
Shorttext	INF-IS-68	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Wolf-Tilo Balke
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 written exam (90 minutes), oral exam (30 minutes) or Take-Home-Exam		
Course achievement	50% of the exercises must be passed		
Module grade composition			

Contents

This module will give a broad overview over all methods that are necessary for building and using data warehouses in large-scale applications. Besides typical techniques for warehouse design, indexing, and online analytical processing (OLAP), also advanced data mining techniques, such as classification, clustering, frequent item set mining, and association rules are covered in the lecture. In paticular,
- Statistical methods in databases
- Knowledge discovery and mining of local structures
- Frequent Item Set Mining and Association Rules
- Hierarchical and partitioning clustering algorithms
- (Linear) classification and support vector machines
- Architecture of data warehouses (ROLAP, MOLAP,...)
- Multi-dimensional data models (star, snowflake)
- Extraction, data transformation and cleaning
- Techniques for online analytical processing (OLAP)
- Storage- and Index structures for data warehouses

Objective qualification

Data warehousing and mining the data within warehouses represent an important basis for corporate decision support. Students understand possible data warehouse architectures and their essential processes and know the details of the major data mining algorithms used, to be able to correctly and meaningfully underpin decisions with data. They are enabled to critically analyze and evaluate the respective application of various algorithms.

Literature

- William H. Inmon: Building the Data Warehouse. Wiley & Sons. ISBN 10: 0-7645-9944-5

- Ralph Kimball, Margy Ross: The Data Warehouse Toolkit. Wiley & Sons. ISBN 10: 0-471-0024-7

- Andreas Bauer, Holger Günzel: Data Warehouse Systeme. dpunkt Verlag. ISBN 10: 3-89864-251-8

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Data Warehousing and Data Mining Techniques				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke		3	Lecture/Exercise	english
Literature				
- William H. Inmon: Building the Data Warehouse. Wiley & Sons. ISBN 10: 0-7645-9944-5 - Ralph Kimball, Margy Ross: The Data Warehouse Toolkit. Wiley & Sons. ISBN 10: 0-471-0024-7 - Andreas Bauer, Holger Günzel: Data Warehouse Systeme. dpunkt Verlag. ISBN 10: 3-89864-251-8				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke		1	Online-exercise	english

Title	Information retrieval and web search engines		
Number	4214690	**Module version**	V2
Shorttext	INF-IS-69	**Language**	english german
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Wolf-Tilo Balke
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 written exam (90 minutes) or oral exam (30 minutes)		
Course achievement	50% of the exercises must be passed		
Module grade composition			

Contents

The module gives an introduction to Web Information Retrieval with particular emphasis on the algorithms and technologies used in the modern search engines. It covers an introduction to traditional text IR, including Boolean retrieval, vector space model as well as tolerant retrieval. Afterwards, the technical basics of Web IR are discussed, starting with a Web size estimation and duplicate detection followed by link analysis and crawling. This leads on to the study of the modern search engine evaluation methods and various test collections. Finally, applications of classification and clustering in the IR domain are discussed. During the module the theoretical basis is illustrated by examples of modern search systems, such as Google, Bing, Yahoo!, etc. In particular,
- Structured vs. unstructured data
- Text retrieval, probabilistic, fuzzy- and vector space models
- Assessment of retrieval quality, precision-recall analysis
- Architecture of Web information systems and search engines
- Structure of the WWW, Web crawling and indexing
- Document clustering and ontologies for search
- Text and link metrics, Page-Rank, HITS, etc.

Objective qualification

Information retrieval techniques play a central role not only in Web search engines, but in all kinds of document-centric applications. Students need to understand different techniques, their typical application areas and limitations, as well as their advantages and disadvantages. They are enabled to choose the right techniques for the respective practical problem and to critically reflect their use in the respective application context.

Literature

- Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval. Cambridge University Press, 2008.
http://www.informationretrieval.org

- Ricardo Baeza-Yates, Berthier Ribeiro-Neto: Modern Information Retrieval. Addison-Wesley, 1999.

- Richard K. Belew: Finding Out About: A Cognitive

Perspective on Search Engine Technology and the
WWW. Cambridge University Press, 2000.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Information Retrieval und Web Search Engines				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke		3	Lecture/Exercise	english
Literature				

- Christopher D. Manning, Prabhakar Raghavan, Hinrich Schütze: Introduction to Information Retrieval. Cambridge University Press, 2008.
http://www.informationretrieval.org

- Ricardo Baeza-Yates, Berthier Ribeiro-Neto: Modern Information Retrieval. Addison-Wesley, 1999.

- Richard K. Belew: Finding Out About: A Cognitive
Perspective on Search Engine Technology and the
WWW. Cambridge University Press, 2000.

- Cornelis Joost van Rijsbergen: Information Retrieval.
Butterworths, second edition, 1979.
http://www.dcs.gla.ac.uk/Keith/Preface.html

Title	Introduction to Machine Learning		
Number	4215370	**Module version**	V2
Shorttext	INF-ROB-37	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Jochen Steil
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 graded work: Written exam (90 minutes) or oral exam (30 minutes)		
Course achievement			
Module grade composition			

Contents

Fundamental principles and theories of machine learning und the underlying mathematical and statistical methods are introduced and learning problems are formalized. Important fundamental terminology, concepts and methods are treated, in particular for regression, among those are
- model selection, machine learning bias vs. parameter optimization
- training, test and validation
- generalization, overfitting, regularization
- linear regression, generalized linear models
- non-linear models, neural networks
- classification
- estimatimation, unbiased minimal variance estimators
- concept learning, decision trees, random forests
- methods of lazy learning
- unsupervised learning
- Gaussian mixtures, Gaussian mixture regression
- Unified Regression Model

Objective qualification

With successful completion of the module, the students possess the following knowledge and capabilities. They are able to
- understand and correctly apply basic concepts of machine learning
- analyse and formalize a machine learning problem
- distinguish between typical machine learning methods
- select a suitable method for a learning problem
- compare and judge machine learning methods wrt their capacity
- implement machine learning methods and apply them practically
apply and parametrise respective tools
- judge strength and weaknesses of machine learning in applications
- recognize ethical issues in the application of machine learning

Literature

Bishop, Pattern Recognition & Machine Learning, Springer, 2006 Mitchell, Machine Learning, McGraw-Hill, 1997 script or slides, further references will be announced in the course

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Introduction to Machine Learning				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sinan Barut Rania Rayyes	Heiko Donat Jochen Steil	4	Lecture/Exercise	english
Literature				
Bishop, Pattern Recognition & Machine Learning, Springer, 2006 Mitchell, Machine Learning, McGraw-Hill, 1997 script or slides, further references will be announced in the course				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sinan Barut Rania Rayyes		2	Exercise	english

Title	Visualization Techniques		
Number	4216340	**Module version**	
Shorttext	INF-CG-34	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	2 / 5,0	**Module owner**	Marcus Magnor
Workload (h)			
Class attendance (h)	28	**Self studying (h)**	122
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	1 Presentation		
Module grade composition			

Contents

- History of visualizaton
- Visualization form an information-theoretic perspective
- Aspects of visual perception theory
- visualization and cognition
- Information visualization techniques
- Interactivity in visualization

Objective qualification

This course offers an overview of computer graphics visualization. It conveys the psychological foundations of visual information perception and provides insight into their algorithmic implementation as basis for various visualization techniques. Graduates of this course will be familiar with relevant aspects of visual perception and cognition theory as well as algorithmic concepts of
visualization.

Literature

- Ward, Grinstein, Keim: Interactive Data Visualization, AK Peters 2010
- Ware: Information Visualization, Elsevier 2012
- Munzner: Visualization Analysis and Design, 2014

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Visualization Techniques				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Susana Castillo Alejandre		2	Lecture	english

Title	Image Aspects		
Number	4216350	**Module version**	
Shorttext	INF-CG-35	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	2 / 5,0	**Module owner**	Marcus Magnor
Workload (h)			
Class attendance (h)	28	**Self studying (h)**	122
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	1 Presentation		
Module grade composition			

Contents

- Physical foundations of image formation
- Statistical and other properties of natural images
- Physiology of visual perception
- Biological evolution of the human visual system
- Optical illusions and what they are good for
- Relationship between images and visual information
- Visual arts as experimental neuroscience

Objective qualification

This course offers insight into the formation, perception, and cognition of images. The natural phenomenon of images will be considered from the viewpoint of physics, information theory, neuroscience, and arts history. Graduates of this course will be familiar with relationships between optics, digital image processing, image statistics, visual perception, cognitive science and visual arts

Literature

- Donald Hoffman: Visual Intelligence. Norton, 1998.
- Simon Ings: A Natural HIstory of Seeing. Norton, 2007.
- Patrick Cavanagh: The Artist as Neuroscientist. Nature, vol. 434, March 2005.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Image Aspects				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Susana Castillo Alejandre Sascha Fricke Marcus Magnor		2	Lecture	english
Literature				
- Donald Hoffman: Visual Intelligence. Norton, 1998. - Simon Ings: A Natural History of Seeing. Norton, 2007. - Patrick Cavanagh: The Artist as Neuroscientist. Nature, vol. 434, March 2005.				

Title	Python Lab		
Number	4217850	**Module version**	
Shorttext	INF-MI-85	**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Tim Kacprowski
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	1 Team-based development and documentation of a data science software tool		
Module grade composition			

Contents

- Introduction to Python
- Introduction to explorative data analysis in Python
- Statistical data analysis
- Unsupervised machine learning
- Supervised machine learning
- Critical assessment of machine learning

Objective qualification

After successful completion of this module, students will have the competence to apply Python for designing and implementing small to medium software projects and analytic workflows with a focus on statistics and machine learning. During an interactive learning phase during which the students will be able to apply common packages such as scikit-learn, and they will be able to
synthesize analysis workflows for diverse data science questions. These workflows will be presented and discussed in a mini-conference among the students. After the mini-conference, students will form small teams to develop data science software tools which will be presented during the closing event. They will gain the competence to critically evaluate machine learning workflows.

Literature

tba

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Python Lab				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Kacprowski	Simone Scharke	3	Internship	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Kacprowski Simone Scharke		1	Colloquium	english

Title	Advanced Software Engineering Lab		
Number	4220370	**Module version**	V2
Shorttext	INF-SSE-37	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Sandro Süß
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: software development. Assessment of skills and effort by the supervisor		
Course achievement			
Module grade composition			

Contents

Paradigms of software engineering (OO, components, …)

- Modelling
- Frameworks
- Component technologies
- Software/System architectures
- Patterns of software development
- Technical Tools
- Practical application of learned concepts

Objective qualification

After completing this module, the students have a profound comprehension in developing complex software systems. They gained practical experience in running software development projects and quality assurance of the results. They are capable of understanding the task, convert it in a software architecture, implementing the architecture, and testing the whole system.

Literature

Project-specific

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Kamil Rosiak Ina Schaefer		4	Internship	english

Title	Software Architecture		
Number	4220400	**Module version**	V2
Shorttext	INF-SSE-50	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Sandro Schulze
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			
Contents			
Objective qualification			
Literature			
Frank Buschmann u.a. "A System Of Patterns" sowie spezifische Literatur zu einzelnen Kapiteln			

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Lukas Linsbauer Kamil Rosiak		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Lukas Linsbauer Kamil Rosiak		2	Exercise	english

Title	Cloud Computing		
Number	4223450	**Module version**	V2
Shorttext	INF-VS-45	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Rüdiger Kapitza
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	non-graded work: Successful completion of the homework assignments: Every assignment must be completed with at least 30% of the attainable points, and 50% of the total points across all assignments must be achieved.		
Module grade composition			

Contents

* Overview of Cloud Computing
* Development of cluster, grid and, utility computing towards Cloud Computing
* Effects on the economy (cost pressure and energy consumption) and society (e.g. data protection)
* Fundamentals of distributed programming (Web services/SOAP/REST)
* Fundamental technology and architecture
* Virtualization as the basis of Cloud Computing
* Concepts for hardware virtualization (e.g. Xen, KVM or, VMWare ESX)
* Advantages and disadvantages of virtualization (e.g. in regards to performance and maintainability)
* Infrastructure as a Service with the example of Eucalyptus and Amazon EC2
* Deployment and administration of distributed applications
* Distributed file systems for cloud applications
* Provisioning of reliable mass storage based on unreliable components
* Distributed programming für data-heavy cloud applications
* Scalable processing of big data
* Interoperability and multi-cloud
* Fault-tolerance and security in a cloud computing context
* Current research trends (e.g. new programming languages, intrusion-resistant systems)

Objective qualification

After completing this module, the students know the fundamentals, methods and, techniques of Cloud Computing. Further, the students know existing Cloud Computing techniques and can develop and assess applications in this setting.

Literature

* A view of cloud computing

M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, and M. Zaharia. A view of cloud computing.
Communication of the ACM, 53(4):50-58, 2010.
Cloud computing: An overview M. Creeger.

* Cloud computing: An overview.Queue, 7(5):3-4, 2009. Advisor-Creeger, Mache.

Further literature can be found on http://www.ibr.cs.tu-bs.de/courses/

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Rüdiger Kapitza		2	Online-lecture	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Informatik Rüdiger Kapitza		1	Online-exercise	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Informatik Rüdiger Kapitza		1	Online-exercise, small group	german

Title	Computational Geometry		
Number	4227250	**Module version**	V2
Shorttext	INF-ALG-25	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes)		
Course achievement	nongraded work: 50% of the exercises must be passed		
Module grade composition			

Contents

• Geometric problems and data structures
• Convex hulls
- Closest pairs
- Voronoi diagrams
- Point triangulation
- Polygon triangulation
- Tour problems
- Other advanced research topics

Objective qualification

Participants know basic modeling for geometric algorithms.
They can gauge the algorithmic difficulty of geometric problems and
formulate appropriate objectives. They can master different solution techniques
and are capable of developing algorithmic methods for new problems.
They understand the practical relevance of problems and solutions.

Literature

Computational Geometry: Algorithms and Applications
Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf
Springer Verlag, 2nd edition (2000)

Algorithmische Geometrie
Rolf Klein
Springer, Heidelberg, 2005.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Computational Geometry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		4	Lecture/Exercise	english
Literature				
Computational Geometry: Algorithms and Applications Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf Springer Verlag, 2nd edition (2000) Algorithmische Geometrie Rolf Klein Springer, Heidelberg, 2005.				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		1	Exercise	english

Name of the course				
Computational Geometry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		1	Exercise, small group	english
Literature				
Computational Geometry: Algorithms and Applications Mark de Berg, Marc van Krevel, Mark Overmars, Otfried Schwarzkopf Springer Verlag, 2nd edition (2000) Algorithmische Geometrie Rolf Klein Springer, Heidelberg, 2005.				

Title	Approximation Algorithms		
Number	4227270	**Module version**	V2
Shorttext	INF-ALG-27	**Language**	
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Sandor Fekete
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (120 minutes) or oral exam (30 minutes)		
Course achievement	non-graded work: 50% of the exercises must be passed		
Module grade composition			

Contents

- A basic introduction to NP-completeness and approximation
- Approximation for vertex and set cover
- Packing problems
- Tour problems and variations
- Current research problems

In the context of various problems, a wide spectrum of techniques and concepts will be provided.

Objective qualification

Participants know the necessity and role of approximation algorithms. They can master the most important techniques for analysis and complexity of approximation algorithms for designing, including the validity of upper and lower bounds.

Literature

- Vijay V. Vazirani: Approximation Algorithms. 1st edition. Springer Verlag, 2001.

- Dorit Hochbau: Approximation Algorithms for NP-hard Problems. Course Technology Inc, 1996.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Approximation Algorithms				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		4	Lecture/Exercise	english
Literature				
- Vijay V. Vazirani: Approximation Algorithms. 1st edition. Springer Verlag, 2001. - Dorit Hochbau: Approximation Algorithms for NP-hard Problems. Course Technology Inc, 1996.				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		1	Exercise, small group	english german

Title	Solving NP-hard Optimization Problems (lab)		
Number	4227290	**Module version**	
Shorttext	INF-ALG-29	**Language**	english
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Sandor Fekete
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	active participation and final presentation		
Module grade composition			

Contents

This lab aims at finding provably optimal solutions of NP-hard optimization problems, with the objective of practical methods for solving benchmark instances of interesting size. This is based on powerful mathematical methods (such as integer programming) and sophisticated
solution software (such as CPLEX and Gurobi).

Objective qualification

Participants understand theory and practice of dealing with NP-hard problems. They can master exact solution methods, in particular based on integer linear
programming. They have gained experience with implementing, testing and refining practical
techniques and software, including the generation of benchmark instances, and visualization of results
and performance.

Literature

- The Traveling Salesman Problem: A Computational Study (Princeton Series in Applied Mathematics). Applegate, David L., Bixby, Robert E., Chvátal, Vašek, Cook, William J., 2007.
- In Pursuit of the Traveling Salesman - Mathematics at the Limits of Computation (Princeton University Press). Cook, William J., 2011

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		3	Internship	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		1	Colloquium	english

Title	Machine Learning for Computer Security		
Number	4229010	**Module version**	V2
Shorttext	INF-ISS-01	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Konrad Rieck
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	The module "Einführung in die IT-Sicherheit" (Introduction to Computer Security) is recommended as preparation for this course.		
Expected performance/ Type of examination	graded work (examination): written exam (90 minutes) or oral exam (20 minutes)		
Course achievement	non-graded work: presentation of a solved homework task in the exercises		
Module grade composition			

Contents

- Principles of machine learning for computer security
- Feature spaces and kernel functions
- Attack detection using machine learning
- Malware analysis using machine learning
- Vulnerability discovery using machine learning
- Further applications of machine learning for computer security

Objective qualification

After completing this course, the students possess the following knowledge and capabilities. They are able to …
- differentiate different types of learning algorithms
- identify the application of learning algorithms in computer security
- design approriate feature spaces for learning algorithms
- explain learning algorithms for classification and anomaly detection
- develop learning-based methods for attack detection
- explain learning algorithms for clustering and dimension reduction
- develop learning-based methods for malware and vulnerability analysis
- differentiate methods for evading learning-based methods

Literature

- Duda, Hart and Stork: Pattern Classification. Wiley & Sons, 2001
- Shawe-Taylor & Cristianini. Kernel Methods for Pattern Analysis. Cambride, 2004
- Gollmann: Computer Security. Wiley & Sons, 2011
- Szor: The Art of Computer Virus Research and Defense. Addison-Wesley, 2005

Further references will be announced in the course.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Konrad Rieck		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Konrad Rieck		2	Exercise	english

Title	Data Science Seminar		
Number	4299990	**Module version**	
Shorttext	INF-STD-99	**Language**	english
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 Presentation		
Course achievement			
Module grade composition	The grade is determined by the active participation in the seminar and the quality of the presentation and the accompanying paper.		

Contents

The cousre content has a mandatory relation to topics of data science. The concrete course content in the seminar depends on the subject area worked on and may vary each semester.

Objective qualification

- The students are able to independently familiarize themselves with a scientific Topic.
- They are able to prepare the topic and present it in an oral presentation.
- The students are able to use adequate presentation technique and rhetorical skills.

Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Seminar in Theoretical Computer Science Master				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Roland Meyer		3	Seminar	english
Literature				
Literature sources vary - depending on the chosen seminar topic.				

Name of the course				
Seminar Databases and Information systems				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Wolf-Tilo Balke		3	Seminar	english german
Literature				
Literature sources vary - depending on the chosen seminar topic.				

Name of the course				
Seminar on Computer Graphics (Master)				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Susana Castillo Alejandre Sascha Fricke Marcus Magnor		3	Seminar	english

Name of the course				
Computer Vision Seminar (Master)				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Martin Eisemann Steve Grogorick		3	Seminar	english
Literature				
Die Literaturquellen variieren, je nach gewähltem Thema.				

Name of the course				
Medical Informatics Seminar for Master Students				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Mostafa Haghi		3	Seminar	english

Name of the course				
Seminar Data Science in Biomedicine Master				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Kacprowski Simone Scharke		3	Seminar	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tobias Pett Ina Schaefer		3	Seminar	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christian Dietrich Christian Werner		3	Seminar	english

Name of the course				
Algorithmics Seminar				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete		3	Seminar	english ger-man
Literature				
Literature sources vary - depending on the chosen seminar topic.				

Title			
Number	4227300	**Module version**	V2
Shorttext		**Language**	english
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Sandor Fekete
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents
Objective qualification
Literature
G. Di Battista & P. Eades & R. Tamassia & I.G. Tollis: Graph Drawing, Algorithms for the Visualization of Graphs M. Kaufmann & D. Wagner (eds): Drawing Graphs T. Nishizeki & N. Chiba: Planar Graphs, Theory and Algorithms Relevant research articles

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Informatik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Graphs, Geometry, and Algorithms				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sandor Fekete			Lecture/Exercise	german

Methods and concepts of Mathematics	
ECTS	25

Title	Algorithms and complexity for quantum computing		
Number	1294480	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Fundamentals from mathematics and physics for quantum computers
- Computational model for quantum computers
- Central algorithms for the quantum computer model
- Relation to complexity

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- master the fundamentals to understand the model of a quantum computer
- know the algorithmic applications of this model
- know and understand the quantum computer model in light of the theory complexity

Literature

wird in der Veranstaltung bekannt gegeben

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		3	Lecture/Exercise	english
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		1	Exercise	english
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Title	Computational Algbraic Geometry		
Number	1294470	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- the Euclidean algorithm
- Factoring polynomials over finite fields
- Factoring polynomials over Z and Q
- Primality tests and factoring of integers
- Rings: polynomial ring and ideals

Gröbner bases and S polynomials

- Buchberger's algorithm for calculating Gröbner bases
- Application in the algebraic solution of non-linear systems of equations
- Symbolic integration and symbolic summation

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- understand the basic concepts of computer algebra techniques in theory and practice, such as the Euclidean algorithm and Gröbner bases, their calculation and application
- understand number theoretic and algebraic techniques and are able to apply and analyze them
- are able to calculate factorizations and to apply and analyze methods to solve systems of nonlinear equations and for working with algebraic objects

Literature

- Von zur Gathen, Gerhard, Modern Computer Algebra, Cambridge University Press

- Adams, Loustauanau, An Introduction to Gröbner Basis, AMS, 1991

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Computational Algebraic Geometry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
		6	Lecture/Exercise	english

Title	Discrete Optimization		
Number	1294460	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Efficiently solvable combinatorial and integer optimization tasks.
- Integral polyhedra
- Relaxation, duality und decomposition
- NP-hard combinatorial optimization tasks
- NP-hard integer optimization tasks
- NP-hard mixed-mixed optimization tasks
- Branch & Bound, Branch & Cut
- Dynamic programming
- Approximation algorithms
- Selected applications (industry, economy, computer science, ...)

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand combinatorial and discrete optimization problems
- understand the notions and results of theory of complexity
- understand the important theorems, proofs and procedures of discrete and combinatorial optimization and are able to apply and analyze them
- know general algorithmic principles and problem structures
- are able to design, apply and analyze algorithms for applications, in particular, for NP-hard problems

Literature
- W.J. Cook, W.H. Cunningham, W.R. Pulleyblank, and A. Schrijver, Combinatorial Optimization, John Wiley and Sons, 1998 - Korte/Vygen, Combinatorial Optimization, Springer, 2003 - A. Schrijver, Combinatorial Optimization, Volume A-C, Springer, 2004 - A. Schrijver, Theory of Linear and Integer Programming, Wiley, 1986 - G.L. Nemhauser, L.A. Wolsey, Integer and Combinatorial Optimization, Wiley, 1988 - L.A. Wolsey, Integer Programming, Wiley, 1998

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		6	Lecture/Exercise	english
Literature				
• W.J. Cook, W.H. Cunningham, W.R. Pulleyblank, and A. Schrijver, Combinatorial Optimization, JohnWiley and Sons, 1998 • Korte/Vygen, Combinatorial Optimization, Springer, 2003 • A. Schrijver, Combinatorial Optimization, Volume A-C, Springer, 2004 • A. Schrijver, Theory of Linear and Integer Programming, Wiley, 1986 • G.L. Nemhauser, L.A. Wolsey, Integer and Combinatorial Optimization, Wiley, 1988 • L.A. Wolsey, Integer Programming, Wiley, 1998				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		2	Exercise, small group	english

Title	Dynamic Optimization		
Number	1294450	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Modeling dynamic processes via ODE and DAE
- Theory of the initial value problem for ordinary differential equations (ODE) and differential algebraic (DAE) equations
- Marginal value problem, solution via single and multi shooting methods
- Modeling and transformation of optimal control problems
- The Bellmann principal
- Direct, indirect, sequential and simultaneous approaches, including e.g. Pontryagin's Maximum Principal, Single Shot method, collokation methods, multi shooting methods, dynamic optimization, the Hamilton-Jacobi-Bellman-Equality
- Structures and their use in direct multi shooting methods
- Parameter estimation and dynamic problems
- The generalized Gauß-Newton-method, local contraction und convergence
- Statistics of the generalized Gauß-Newton-method
- Optimal experimental design
- Model discrimination

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the problems of optimal control, parameter estimation, optimal experimental design and model discrimination

- know and understand the different fundamental approaches in the field of optimal control are are able to apply and analyze them
- are able to analyze, interpret, refine and enhance the methods, especially to increase the efficiency of numerical algorithms exemplified for optimal control

Literature

M. Gerdts: Optimal Control of ODEs and DAEs, De Gruyter, 2011.
A. E. Bryson, Y.-C. Ho: Applied Optimal Control: Optimization Estimation an Control, Routledge, 1975.
G. Feichtinger, R. F. Hartl: Optimale Kontrolle Ökonomischer Prozesse, De Gruyter, 1986.
Y. Bard: Nonlinear Parameter Estimation, Academic Press, 1974.
D. Bertsekas: Dynamic Programming & Optimal Control, Athena Scientific, 2005.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course

Lecturer	Additional lecturers	SWS	Eventtype	Language
Christian Kirches		6	Lecture/Exercise	english

Name of the course

Lecturer	Additional lecturers	SWS	Eventtype	Language
Christian Kirches		2	Exercise, small group	english

Title	Introduction to Quantum Information Theory		
Number	1294540	**Module version**	V2
Shorttext	IntrQuantInfTH	**Language**	english german
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements	A basic knowledge of classical information theory is recommended		
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Vectors and Operators,
- States, Observables, Statistics,
- Composite Systems and Entanglement,
- Classical Entropy and Information,
- The Classical-Quantum Channel,
- Quantum Evolutions and Channels,
- Quantum Entropy and Information Quantities

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- acquainted with the basic objects, constructions, and mathematical theorems and their proofs of quantum information theory
- obtain an understanding of the similarities of, and the fundamental differences between, classical information theory and quantum information theory
- learn about applications of quantum information theory in quantum computing and communication.

Literature

- A. Holevo: Quantum Systems, Channels, Information

-....

-...

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Volker Bach		3	Lecture/Exercise	english german
Literature				
A. Holevo: Quantum Systems, Channels, Information				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Volker Bach		1	Exercise, small group	german

Title	Inverse problems		
Number	1294430	**Module version**	V2
Shorttext	MAT-STD7-43	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Mathematical knowledge in 'Introduction to Numerical Analysis' is required. Knowledge in ‚Functional Analysis‘ is helpful.		
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Compact operators, pseudo inverse
- Regularization methods, order optimality
- Tikhonov regularization, Landweber iteration, the CG method
- A-priori and a-posteriori parameter choice
- Nonlineare Problems, convex variational regularization methods

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- know and understand the notion of well- and ill-posedness and of regularization methods and their properties
- are able to understand, analyze and apply methods to approximately solve ill-posed problems and use them with mathematical software

Literature

- Rieder, Keine Probleme mit Inversen Problemen, Vieweg, 2003 (deutsch)
- Engl, Hanke, Neubauer, Regularization of Inverse Problems, Kluwer, 2000 (english)

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dirk Lorenz		3	Lecture/Exercise	english
Literature				
• Rieder, Keine Probleme mit Inversen Problemen, Vieweg, 2003 (deutsch) • Engl, Hanke, Neubauer, Regularization of Inverse Problems, Kluwer, 2000 (english)				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dirk Lorenz		1	Exercise	english

Title	Continuous Optimization in Data Science		
Number	1294420	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Linear and Nonlinear Regression
- Matrix Completion
- Low Rank Parameterization
- Nonnegative Matrix Factorisation
- Sparse Inverse Covariance
- Sparse Principal Component Analysis
- Nichtlineare Support Vector Machines
- Logistic Regression
- Deep Learning
- selected applications

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- remember and understand exemplary problems in Data Science
- master selected problem solving abilities using methods of continuous optimization and are able to apply them
- understand theory and algorithms of continuous optimization in the context of statistical phenomena of the data basis

Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christian Kirches		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christian Kirches		1	Exercise	english

Title	Machine learning with neural networks		
Number	1294410	**Module version**	V2
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Multilayer neural networks
- Backprogagation-Algorithms
- Regularization
- Stochastic gradient methods
- Second order optimization methods

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- know and understand neural networks and are able to characterize them in mathematical terms
- know different use cases and applications of neural networks
- know and understand optimization methods for the training of neural networks and are able to apply them

Literature

- I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, MIT Press, 2017
- C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Machine learning with neural networks				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Brauer Timo de Wolff		3	Lecture/Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Brauer Timo de Wolff		1	Online-exercise, small group	english

Title	Mathematical Foundations of Data Science		
Number	1294490	**Module version**	V2
Shorttext	MathFound_DS	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

-foundations of supervised learning, different loss functions and risk analysis
-Regression-and Classification problems in reproducing kernel Hilbert spaces
-empirical risk minimization, regularization, Gradient Descent and rates of convergence

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- understand the applied methods and are able to analyze these
- master the foundations of the field
- are able to them into a larger context

Literature

1. Steinwart/Christman, „Support Vector Machines", Springer, 2006
2. Györfi/Kohler/Krzyzak/Walk, „A distribution free theory of nonparametric regression", Springer, 2002
3. Wainwright, "High-dimensional statistics", Cambridge Series in Statistical and Probabilistic Mathematics

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Mathematical Foundations of Data Science				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Nicole Mücke		4	Lecture/Exercise	english

Title	Mathematical Foundations of Information Theory and Coding Theory		
Number	1294600	**Module version**	V2
Shorttext	MathFoundInfThCodTh	**Language**	english german
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 oral exam (20-30 minutes) according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework or presentation according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Kraft Inequality and McMillan's Theorem
- Huffman Codes
- Stochastic Processes
- Entropy and Entropy Rates
- The Shannon-McMillan-Breiman Theorem
- Universal Codes and the Lempel-Ziv Code
- Rate Allocation

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- understand the applied methods and are able to analyze these
- master the foundations of the field
- are able to them into a larger context

Literature

- Cover & Thomas „Elements of Information Theory“ (Wiley)

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
			Lecture/Exercise	english german

Title	Model Order Reduction		
Number	1294500	**Module version**	V2
Shorttext	MAT-STD7-5	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) or "Portfolio" according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- numerical methods for model order reduction for linear (and nonlinear) systems, in particularly modal truncation (eigenvalue-based methods, singular value decomposition-based methods)
- Proper orthogonal decomposition (POD)/Karhunen-Loeve decomposition
- (discrete) empirical interpolation method ((D)EIM)
- Reduzierte Basis Methoden für parameterabhängige Systeme
- Greedy methods, certification, Applications.

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- understand the concept of model reduction
- know and understand the most important methods of (non)linear model reduction
- are able to analyze the method and understand of the basic limits of the applicability of the methods
- are able to interpret the goodness and optimality of the achievable approximation

Literature

will be announced in the lecture

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Carmen Gräßle		2	Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Carmen Gräßle		4	Lecture/Exercise	english
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Title	Nonnegativity and polynomial optimization		
Number	1294380	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Classic nonnegativity and sums of squares (SOS)
- Semidefinite optimization: reference to SOS, moments, spectrahedra
- Positivstellensätze: Basics of polynomial optimization under constraints
- Polynomial optimization in practice: Software and solvers; Applications; Theory vs. Practice

In addition, for example:

- Tarski-Seidenberg theorem and CAD
- Stability and hyperbolic optimization
- AGI forms
- References to theoretical computer science

Objective qualification

The students

- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the core statements of real algebraic geometry on nonnegativity and its relation to polynomial optimization
- know and understand the common methods in polynomial optimization in theory and practice

Literature

- S. Basu, R. Pollack, M.F. Roy: "Algorithms in real algebraic geometry", Springer 2003.
- G. Blekherman, P.A. Parillo, R.R. Thomas "Semidefinite Optimization and Convex Algebraic Geometry", MOS-SIAM Series on Optimization, 2013.

- J.B. Lasserre: "An Introduction to Polynomial and Semi-Algebraic Optimization", Cambridge University Press, 2015.
- J.B. Lasserre: "Moments, Positive Polynomials and Their Applications", Imperial College Press, 2009.
- M. Marshall: "Positive Polynomials and Sums of Squares", Mathematical Surveys and Monographs, AMS, 2008.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Timo de Wolff		6	Lecture/Exercise	english

Literature

- S. Basu, R. Pollack, M.F. Roy: "Algorithms in real algebraic geometry", Springer 2003.
- G. Blekherman, P.A. Parillo, R.R. Thomas "Semidefinite Optimization and Convex Algebraic Geometry", MOS-SIAM Series on Optimization, 2013.
- J. B. Lasserre: "An Introduction to Polynomial and Semi-Algebraic Optimization", Cambridge University Press, 2015.
- J. B. Lasserre: "Moments, Positive Polynomials and Their Applications", Imperial College Press, 2009.
- M. Marshall: "Positive Polynomials and Sums of Squares", Mathematical Surveys and Monographs, AMS, 2008.

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Timo de Wolff		2	Exercise	english

Title	Nonparametric Statistics		
Number	1294370	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Kernel and local polynomial estimators for densities and regression functions
- Bias-variance decomposition
- Optimal asymptotical convergence rates under smoothness conditions
- Asymptotical risk bounds
- nonparametric estimators under shape constraints (monotonicity or convexity)
- bandwidth selection
- Bootstrap methods

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand kernel estimators and other smoothing techniques
- know and understand the basic methodological approach
- know and understand Bootstrap procedures and further resampling methods and are able to apply them

Literature

wird in der Veranstaltung bekannt gegeben

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jens-Peter Kreiß		3	Lecture/Exercise	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jens-Peter Kreiß		1	Exercise	german

Title	Numerical Linear Algebra in Data Science		
Number	1294360	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

Students learn basic concepts and tools from numerical linear algebra that are used in data mining. After the course, students should be able to solve problems in data mining on their own using the methods discussed in the course.

Ideas and algorithms from numerical linear algebra are important in several areas of data mining. This course gives an introduction on the information extraction from data by means of concepts and tools from numerical linear algebra. The following topics are covered in the course: low-rank-approximation of matrices, methods for least-squares-problems, the singular value decomposition, nonnegative matrix factorizations, eigenvalue algorithms.

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the methods of linear algebra in the context of data mining
- are able to anaylze and evaluate problems in this field and to develop methods for their solution on the basis of the content of the lecture

Literature

- Lars Eldén, „Matrix Methods in Data Mining and Pattern Recognition“, Society for Industrial and Applied Mathematics, 2019
- James Demmel, „Applied numerical linear algebra“, Society for Industrial and Applied Mathematics, 1997
- Lloyd Trefethen, David Bau, „Numerical linear Algebra“, Society for Industrial and Applied Mathematics, 1997

- Gene Golub, Charles van Loan, „Matrix Computations“, Johns Hopkins University Press, 2013

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Title	Numerical Methods and Learning from Data		
Number	1294350	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or "Portfolio" according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Randomized methods, e.g., matrix multiplication, randomized decompositions (QR, SVD), rank computation
- Low rank methods, basics of compressed sensing
- Numerical methods for structured matrices (FFT, circulants, Toeplitz-matrices, Incidence matrices) and their applications
- Basics of stochastics and optimization, particularly stochastic gradient descent method
- Basics of Learning, e.g. Deep Learning
- Realization of numerical methods in a programming environment such as MATLAB

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand numerical methods that are employed for Data Science applications such as Deep Learning or Machine Learning
- know and understand basics of machne learning, e.g. deep neural networks

Literature

Gilbert Strang: Linear Algebra and Learning from Data, Wellesley – Cambridge Press, 2019

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Title	Optimization in machine learning and data analysis 1		
Number	1294340	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements	Knowledge of Linear Algebra, Analysis, Linear and combinatorial optimization and Discrete optimization is required, as well as basic knowledge of probability theory.		
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

The lecture contains models, criteria and methods for the analysis of vector data as graphs and to analyze networks, in particular, centrality and clustering, as well as optimization methods and fundamental analyses for different forms of machine learning. This may cover deep, artificial neural networks.

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand optimization methods for machine learning and machine learning in algorithms for optimization, in particular, discrete optimization and network optimization

Literature

will be announced in the lecture

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		1	Exercise	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		3	Lecture/Exercise	german
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Title	Risk and Extreme Value Theory		
Number	1294330	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements	Mathematical knowledge in "Wahrscheinlichkeitstheorie" is required.		
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Modeling of aggregate claim distributions
- Compound Poisson processes
- Premium calculation
- Approximation of aggregate claim distributions
- Claim reservation
- Re-insurance and premium split
- Ruintheory: Cramèr-Lundberg model, Lundberg inequality and Lundberg coefficient
- Risk measures: Value-at-Risk, expected shortfall, coherence
- Copulas with applications and rank correlations
- Credibility theory und credibility estimator and Bühlmann-Straub model
- Extreme value theory: Basics, extreme value distributions, central limit theorems and domains of attraction

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the fundamental methods of non-life insurance mathematics including premium calculation, provisions tariffing and claim reservation and are ably to apply them
- know and understand classical ruin theory, re-insurance and extreme value statistic

Literature

will be announced in the lecture

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Risk and Extreme Value Theory				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
		3	Lecture/Exercise	english

Title	Statistical methods: Optimality and high dimensionality		
Number	1294390	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Optimal statistical decisions
- Asymptotical statistical inference
- Statistical methods for high-dimensional regression and classification
- Bagging, Boosting and Random Forests
- Volatility modelling
- Statistical inference for GARCH models and heteroscedastic time series models
- Application to real data

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- remember and understand core methods of mathematical statistics in order to assess power and optimality of statistical methods
- are able to construct (optimal) confidence sets
- understand selected statistical methods for high dimensional data
- understand the basic probabilistic treatment of financial time series
- understand properties of statistical methods in theory and application
- are to model real data

Literature

wird in der Veranstaltung bekannt gegeben

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jens-Peter Kreiß		6	Lecture/Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jens-Peter Kreiß		2	Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
		6	Lecture/Exercise	english german

Title	Statistical and machine learning		
Number	1294310	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 7,0	**Module owner**	
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	154
Compulsory requirements	Mathematical knowledge in "Einführung in die Stochastik", "Wahrscheinlichkeitstheorie" and linear regression is required.		
Recommended requirements	Mathematical knowledge in programming with R or C++, in "Mathematical Statistics" and "Nonparametrics" is helpful.		
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (90 minutes) or 1 oral exam (20-30 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Supervised learning: linear regression, logistic regression, support vector machines - Decision Trees, k-means, kernel smoothing, random forests, bagging and boosting, neural nets
- Unsupervised learning: principal component analysis, clustering
- Model fitting: Selection of smoothing parameter via cross validation or Bootstrap

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the basic ideas and methods in machine and statistical learning
- are able to analyze and evaluate these method and apply them to practical problems

Literature

– G. James, D. Witten, T. Hastie, R. Tibshirani:„An Introduction to Statistical Learning“, Springer 2013
– T. Hastie, R. Tibshirani, J. Friedman: „The Elements of Statistical Learning“, Springer 2001
– K. Murphy: „Machine Learning – A probabilistic perspective“, The MIT Press, 2012

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Mathematik		3	Lecture	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Mathematik		1	Exercise, small group	german

Title	Advanced Computerlab		
Number	1294440	**Module version**	
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 5,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	66
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	Homework according or Portfolio to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

Advanced Computerlab Numerical Analysis

The advanced numerics computing lab deals with advanced methods of scientific computing. We will discuss high-level application problems stemming from mathematics in finance, industry or data science. For numerically solving these problems, various numerical methods will be employed most of which have already been presented in courses such as „Numerische Methoden in der Finanzmathematik“, „Numerical Linear Algebra“, „Numerik gewöhnlicher Differenzialgleichungen“ or „Numerical Methods and Learning from Data“. These methods have to be implemented efficiently, if necessary, in parallel and they should be verified for practical examples. In doing so, the possibilities of these methods as well as their limits will be seen. For some demanding numerical subtasks well-established numerical software libraries exist which have proven to be very efficient in many cases. These can be migrated with the students‘ own implementations and one can waive the development of hand-written codes.

Advanced Computerlab Optimization
The goal is to combine advanced knowledge in mathematical optimization with practical planing and realization of large-scale optimization problems. To this end algorithms to solve complex mathematical models of mathematical optimization, partly known from the lectures "discrete optimization", „continuos optimization" or various advanced courses in mathematical optimization, shall be implemented and tested. Thereby, the possibilities and limits will be explored. A sufficiently wide sub-field of optimization may serve as general theme, e.g.
- Algorithms for scheduling, knapsack, coloring or routing problems.
- Algorithms for differentiable or non-smooth non-linear optimization problems with or without constraints.

As well-tested and highly efficient methods are available for central methods, it is important to be able to use such software (e.g. CPLEX, Gurobi, Matlab) for pertaining applications.

Advanced Computerlab Data Science
In the Advanced Computerlab Data Science, current machine learning models are implemented, trained, applied and interpreted in order to work on practical questions on the basis of extensive structured or unstructured data sets. Fundamentals and techniques imparted on a theoretical level (e.g. models and their evaluation, optimization algorithms, interpretation techniques) are applied and expanded in practice by means of functions provided in various frameworks

(e.g. TensorFlow, Keras, Matplotlib). The independent implementation of machine learning models in Python forms a further focus in addition to the use of specialized frameworks.

Advanced Computerlab Statistical Learning
The focus of the Advanced Computerlab Statistical Learning is on well-known machine learning methods. These are mainly considered from the perspective of mathematical statistics. For presented structured and unstructured data, students are taught how to find suitable solutions, how to implement them, e.g. in the statistical software R, and how to interpret the results. Advantages and disadvantages of the methods used as well as the underlying model assumptions are discussed from a probabilistic or statistical point of view. Students have the opportunity to apply their knowledge of probability theory and mathematical statistics acquired in previous courses. One focus of the course is the independent implementation of machine learning models using frameworks such as TensorFlow, mlr3, Keras, among others.

Objective qualification
The students - remember and understand the basic tasks and method of mathematicl algorithms and their praktical appliastion - are able to use mathematical programming tools - are able to apply, analyze and implement mathematical algorithms - are able to document and present mathematical algorithms
Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Brauer Timo de Wolff Matthias Neumann-Brosig		4	Exercise	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Brauer Timo de Wolff Matthias Neumann-Brosig		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Alexander Braumann Jens-Peter Kreiß		2	Lecture	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Alexander Braumann Jens-Peter Kreiß		4	Exercise	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christian Kirches Sebastian Stiller		2	Lecture	english
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christian Kirches Sebastian Stiller		4	Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Matthias Bollhöfer		2	Lecture	german
Literature				
(de) wird in der Veranstaltung bekannt gegeben (en) will be announced in the lecture				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Matthias Bollhöfer		4	Exercise	english

Title	Mathematical Seminar		
Number	1294400	**Module version**	
Shorttext	MAT-STD7-4	**Language**	english german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	2 / 4,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	28	**Self studying (h)**	92
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 "Referat" according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Course achievement			
Module grade composition			

Contents
depending on the seminar chosen
Objective qualification
The students - know selected methods of moderation and presentation of mathematical content and are able to apply them - know different types of information and communication technology and are able to apply them - are able to write mathematical and technical texts, are able to set up correct bibliographies, to excerpt and to develop scientific arguments - are able to asses and evaluate mathematics in the historical and societal contex
Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Methoden und Konzepte der Mathematik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Sebastian Stiller		2	Seminar	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jens-Peter Kreiß		2	Seminar	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Matthias Bollhöfer Heike Faßbender		2	Seminar	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dirk Lorenz		2	Seminar	english ger-man

Data Science in Applications - Engineering

Title	Ecological Modelling		
Number	1116130	**Module version**	
Shorttext	GEA-UA-13	**Language**	english german
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 6,0	**Module owner**	Boris Schröder-Esselbach
Workload (h)			
Class attendance (h)	60	**Self studying (h)**	120
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Examination: Generation and documentation of computer programs		
Course achievement			
Module grade composition			

Contents

[Distribution and population models(VÜ)]
Approaches to and methods of ecological modelling
Theoretical basics for the generation of ecological models (instructed in the exercises)
Application examples of models in ecology and conservation biology
Approaches to species distribution models in statistics and machine learning (parametric, semi-parametric and nonparametric
techniques) Individual-based (agent-based) modelling
Progamming of species distribution models in R (or comparable software)
Progamming of individual-based population models with NetLogo (or comparable software)

Objective qualification

After successful completion of the module, students have knowledge of the key - statistical and machine learning - methods of species distribution modelling. They also have knowledge of the most important approaches to population dynamic modelling. The students are able to apply both modelling methods for dealing with geoecological and conservation biological questions and they know the advantages and disadvantages of these methods. They are capable to visualise and interpret data and models and to check underlying assumptions as well as to evaluate parameter sensitivities.

Literature

- Franklin J 2010: Mapping Species Distributions - Spatial Inference and Prediction.

- Railsback SF, Grimm V 2011: Agent-based and individual-based modeling: A practical introduction.
Additional literature will be provided online.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
In the exercises, we use R (statistical software) and NetLogo. Previous knowledge in programming (preferentially in R) is preconditioned. NetLogo will be newly introduced (no previous knowledge required).
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Anett Schibalski Boris Schröder-Esselbach		4	Lecture/Exercise	german

Title	Fundamentals of Turbulence Modeling		
Number	2512380	**Module version**	
Shorttext	MB-ISM-38	**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	David Rival
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements	Lecture "Fundamentals of Fluid Mechanics"		
Expected performance/ Type of examination	1 Examination element: written exam (90 min) or oral exam (30 min to 45 min)		
Course achievement			
Module grade composition			

Contents

- Numerical simulation of fluid flow
- Overview of computational approaches to turbulent flow (RANS, , LES, DNS)
- RANS: turbulence modeling
- LES: partly resolved turbulence (filtering, modeling of unresolved scales, boundary and initial conditions requirements on numerical scheme and resolution)
- Hybrid RANS-LES
- Applications of scale-resolving simulations

Objective qualification

Students acquire the concepts and fundamentals of engineering turbulence modeling. Students learn the underlying physics, assumptions and application of various turbulence models. They know the assumptions, governing equations, and the numerical algorithms of each methodology. Students are able to explain and evaluate the results of scale-resolution simulations in a critical way. At the end of the course, students will be able to use concepts from turbulence modeling for the solution of problems within the engineering field.

Literature

1. Turbulence Modeling for CFD, Third edition, by David C. Wilcox
2. Large Eddy Simulation for Incompressible Flows: An Introduction, P. Sagaut, 2005
3. Computational Techniques for Fluid Dynamics, Volume I, Springer, 1997, C.A.J. Fletcher

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
David Rival		3	Lecture/Exercise	english
Literature				

1. Turbulence Modeling for CFD, Third edition, by David C. Wilcox
2. Large Eddy Simulation for Incompressible Flows: An Introduction, P. Sagaut, 2005
3. Computational Techniques for Fluid Dynamics, Volume I, Springer, 1997, C.A.J. Fletcher

Title	Automotive Software Engineering		
Number	4220450	**Module version**	V2
Shorttext	INF-SSE-52	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Ina Schaefer
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: portfolio		
Course achievement	non-graded work: all practical tasks must have been successfully completed.		
Module grade composition			

Contents

- Fundamentals and boundary conditions for software development in the automotive sector
- Modeling techniques
- Development processes and methodology
- quality assurance
- Tools and tool sets
- case studies

Objective qualification

After completing this module, students will know the essential fundamentals and suitable methods and tools for software development in the automotive sector. The students can apply basic software development methods of embedded systems and the techniques for complexity and quality management.

Literature

- J. Schäuffele, Th. Zurawka: Automotive Software Engineering. Vieweg Verlag 2003.
- O. Kindel, M.Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis. dpunkt-Verlag 2009.
- P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme. Elsevier 2005.
- W. Zimmermann, R. Schmidgall: Bussysteme in der Fahrzeugtechnik - Protokolle, Standards und Softwarearchitektur. 4. Auflage. Vieweg 2011.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Ina Schaefer		2	Lecture	german
Literature				
- O. Kindel, M. Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis, dpunkt.verlag, 2009 - P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme, Elsevier, 2005. - Werner Zimmermann Ralf Schmidgall, Bussysteme in der Fahrzeugtechnik Protokolle, Standards und Softwarearchitektur, 4. Auflage, Vieweg, 2011. - Schäuffele, Zurawka: Automotive Software Engineering, Vieweg Verlag 2003.				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Ina Schaefer		2	Exercise	german
Literature				
- O. Kindel, M. Friedrich: Softwareentwicklung mit AUTOSAR. Grundlagen, Engineering, Management für die Praxis, dpunkt.verlag, 2009 - P. Liggesmeyer, D. Rombach (Hrsg.): Software Engineering eingebetteter Systeme, Elsevier, 2005. - Werner Zimmermann Ralf Schmidgall, Bussysteme in der Fahrzeugtechnik Protokolle, Standards und Softwarearchitektur, 4. Auflage, Vieweg, 2011. - Schäuffele, Zurawka: Automotive Software Engineering, Vieweg Verlag 2003.				

Title	Basic Coastal Engineering		
Number	4398090	**Module version**	
Shorttext	BAU-STD5-0	**Language**	german
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 6,0	**Module owner**	Nils Goseberg
Workload (h)			
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Written exam (90 min.)		
Course achievement	Presentation (20 min.)		
Module grade composition			

Contents

- Introduction to coastal engineering (sociological and ecological significance of the coastal zone, tasks and future of the coastal engineer)
- Linear and nonlinear wave theories, including areas of validity and application
- Wave transformation in shallow water (shoaling, refraction, breaking) and in interaction with obstacles (reflection, diffraction)
- Formation mechanisms of the sea state, including procedures for its parameterization and prediction
- Formation and prediction of tides in coastal areas and estuaries, including their special forms, significance and benefits
- Formation and prediction of storm surges and design water levels

Insight into the current state of research in various fields of coastal engineering

Objective qualification

After successful completion of the module, students will have a broad and solid basic knowledge of the mechanics of water waves and hydrodynamic processes in the coastal area, which enables them to determine the load, erosion and transport parameters for the required constructive and functional planning of engineering measures.
The students are able to use the linear and nonlinear theory of water waves to calculate the total wave induced current parameters and the associated effects on sediments, structures and other obstacles. By the mediated calculation basics for wave transformation the students can calculate the effects of the bottom in shallow water (shoaling, refraction, wave breaking) as well as of buildings and other obstacles (reflection, diffraction) on the parameters (height, length, direction) of the waves and their stability (refraction criterion) at the given planning location.
On the basis of the acquired basics of the origin, parameterization, mathematical/statistical description and prediction of the sea state, the students are able to determine the design waves for the functional and constructive planning. They can determine the design water levels on the basis of the acquired knowledge on the formation and prediction of tides on open coasts and in estuaries as well as of storm surges on the German North Sea and Baltic Sea coasts. In the seminar, students are enabled to conduct scientific research and to present research results from current publications in an appropriate manner.

Literature
unter anderem / amongst others: - Detailed Presentation Slides of the Lecture, Exercises, Solutions (PDF) - Teaching Platform with educational videos, interactive diagrams, screencasts and lab videos (coastal.lwi.tu-bs.de) - Task Library of the Institute - EAK (2003): Empfehlungen für Küstenschutzwerke. Die Küste, Heft 65, Heide i. Holstein. - Oumeraci, H. (2001): Küsteningenieurwesen. Kapitel 12 in: Lecher, K. et al.: Taschenbuch der Wasserwirtschaft, Berlin. - CEM (2008): Coastal Engineering Manual. Washington, D.C: U.S. Army Corps of Engineers, Online-Ressource. - Dean, Robert G.; Dalrymple, Robert A. (1991): Water wave mechanics for engineers and scientists. Advanced Series on Ocean Engineering, Singapore: World Scientific. - Goda, Yoshimi (2010): Reanalysis of regular and random breaking wave statistics. Coastal Engineering Journal, vol. 52, no.1, JSCE.
Remark
In the Seminar in Coastal Engineering on the topic Data Science & Coastal Engineering, an introduction is given to the use of Python as a universal tool for the evaluation and presentation of data; students will implement and evaluate data and methods from the lecture. The successful completion and submission of code implementations will be credited as study achievement (Studienleistung).

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance
There is an attendance obligation in the presentation seminar.

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Benedikt Bratz Nils Goseberg		1	Seminar	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
		4	Lecture/Exercise	german

Title	Introduction to Finite Element Methods		
Number	4398470	**Module version**	
Shorttext	BAU-STD5-4	**Language**	german
Frequency of offer		**Teaching unit**	Fakultät Architektur, Bauingenieurwesen und Umweltwissenschaften
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			
Contents			
Objective qualification			
Literature			

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Bauingenieurwesen Ursula Kowalsky		2	Exercise	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Bauingenieurwesen Ursula Kowalsky		2	Lecture	english

Title	Railway Timetabling & Simulations		
Number	4398580	**Module version**	
Shorttext	BAU-STD5-5	**Language**	german
Frequency of offer		**Teaching unit**	
Module duration		**Institution**	Institut für Eisenbahnwesen und Verkehrssicherung
Hours per Week / ECTS	5 / 6,0	**Module owner**	
Workload (h)	180		
Class attendance (h)	70	**Self studying (h)**	110
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Portfolio		
Course achievement	term paper (timetable data and simulation results)		
Module grade composition			

Contents

- Basic terms and principles of rail traffic control
- Traffic flow theory in railway systems
- Analytical estimation of the consumed capacity of a railway by applying the compression method
- Use of simulations for capacity research
- Conflict-free train path management
- Use of simulations for quality assessment of timetables

Objective qualification

The students have a fundamental understanding of the models for the estimation of the operational capacity of railway networks. They are familiar with the possibilities and limits of analytical methods and simulations in railway operations research and can select the appropriate method for a given problem. They got practical experience in the use of computer-based scheduling systems and in testing of timetables with different simulation tools.

Literature

Hansen/Pachl (Hrsg.): Railway Timetabling & Operations. 2. Aufl., DVV Media Group, Hamburg 2008
Pachl, J.: Railway Operation and Control. 4th Edition. VTD Rail Publishing, Mountlake Terrace 2018

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Students of Transportation Engineering, Civil Engineering, and Business Engineering (Civil), may enroll for this module as a replacement for the module Bahnbetrieb in the specialisation Spurgeführter Verkehr
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
		5	Lecture/Exercise	german

Title	Deep Learning in Remote Sensing		
Number	4398860	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 5,0	**Module owner**	Markus Gerke
Workload (h)	150 h		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	As it is planned, the students should first take “Machine learning” or any similar course like “Pattern Recognition” in Winter semester and then “Deep learning in Remote Sensing” in Summer semester.		
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

In this module students are introduced to the concepts of deep learning in order to process Remote sensing data. Remote sensing is the science that provides geometric and semantic information about objects at or near the surface of the Earth using the sensors which are installed on satellites or other airborne platforms. Along with fundamentals of remote sensing, some applications like object detection and classification especially on images and also regression algorithms on remote sensing observations will be covered. In the context of image understanding, an introduction to digital image processing will be given, which deals with the application of filters on the images to extract the information which could be used in machine learning and deep learning algorithms. Each of the lectures in this module is supplemented by practical parts to enable the students to process real-world remote sensing datasets, efficiently. After completing the module, students know and understand the most important concepts of deep learning for image analysis. Furthermore, a student is able to implement a selection of algorithms and evaluate the respective result.

Objective qualification

Upon completion of this module, the students will be able to understand basic principles and applications of deep learning and to apply them on Remote Sensing as well as similar problems.

Literature

• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019.
• Pattern Recognition and Machine Learning, Bishop, C. M. 2006
• Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022
• Deep Learning, Goodfellow, Y. Bengio, and A. Courville, MIT Press, 2016
• Deep Learning for Remote Sensing Images with Open Source Software, Rémi Cresson, CRC Press, 2020.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
As it is planned, the students should first take “Machine learning” or any similar course like “Pattern Recognition” in Winter semester and then “Deep learning in Remote Sensing” in Summer semester.
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Exercise	english

Title			
Number	4398870	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in winter term	**Teaching unit**	
Module duration		**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 5,0	**Module owner**	Markus Gerke
Workload (h)	150 h		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

This Module will introduce the fundamental methods at the core of machine learning, including -but not limited to- classification, regression analysis, clustering, and dimensionality reduction. This course is designed for BSc. and MSc. students in different disciplines who employ machine learning algorithms in their fields. Students will learn about the basic concepts of machine learning and will apply the learned concepts on the practical problems using open source libraries from the Python programming ecosystem. The course will also briefly cover neural networks and will be closed by a short introduction to deep learning. Classes on theoretical aspects will be complemented by practical lab sessions. In this course we do not concentrate on a specific type of data and various datasets will be used in the practical example.

Objective qualification

Upon completion of this module, the students will be able to understand basic principles and applications of machine learning and to apply them on practical examples.

Literature

• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019.
• Pattern Recognition and Machine Learning, Bishop, C. M. 2006
• Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022
Further information and material will be provided during the course.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi			Lecture	english
Literature				
• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019. • Pattern Recognition and Machine Learning, Bishop, C. M. 2006 • Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022 Further information and material will be provided during the course.				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Exercise	english

Title	Basic Measurement Methods in Fluid Mechanics		
Number	2512410	**Module version**	
Shorttext	MB-ISM-41	**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	Fakultät für Maschinenbau
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	David Rival
Workload (h)	150		
Class attendance (h)	60	**Self studying (h)**	90
Compulsory requirements			
Recommended requirements	• Knowledge from the bachelor#s degree in fluid mechanics, physics and electrical engineering • In-depth knowledge of fluid mechanics and aerodynamics of aircraft		
Expected performance/ Type of examination	1 examination element: written exam (120 min) or oral exam (30 min)		
Course achievement			
Module grade composition			

Contents

Theory and Experiment, Measurement Uncertainties, Flow visualization methods (smoke, oil flow pictures, laser sheet visualization), pressure measurement, force measurement, hot-wire anemometry, basics of optics, Particle Image Velocimetry (PIV) and its extensions, Schlieren techniques, thermography, pressure sensitive paint, particle measurement techniques

Objective qualification

The students are able to explain mechanical, electrical and optical measurement techniques to determine fluid mechanical quantities like pressure, density, velocity, temperature and shear stress. Beyond the basic principle and the accuracy of the different measurement techniques, the students can evaluate the limitations of the techniques and use methods to improve and expand them. The students are able to apply selected measurement techniques in the laboratory course.

Literature

1. H. Eckelmann: Einführung in die Strömungsmesstechnik, Teubner, 1997
2. W. Nitsche: Strömungsmesstechnik, Springer, 2005
3. C. Tropea, A. L. Yarin, J. F. Foss: Springer Handbook of Experimental Fluid Mechanics, Springer Verlag, 2007
4. H. Oertel sen., H.Oertel jun.: Optische Strömungsmesstechnik, G. Braun Verlag, Karlsruhe 1989
5. M. Raffel, C. Willert, J. Kompenhans: Particle Image Velocimetry, Springer Verlag, 1997
6. W. Merzkirch: Flow Visualization, Acad. Press Inc., 1987
7. Folienskript #Measurement methods in fluid mechanics#

Remark

Language option for students of international and bilingual study programmes:
The course and laboratory are offered in English. The lecture and laboratory notes are available in English.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Laboratory Experimental Fluid Dynamics				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
André Bauknecht		1	Laboratory	english

Name of the course				
Experimental Fluid Dynamics				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
André Bauknecht		2	Lecture	english

Title	Data-Driven Material Modeling		
Number	4398690	**Module version**	
Shorttext	BAU-STD5-69	**Language**	english
Frequency of offer		**Teaching unit**	
Module duration	1	**Institution**	Institut für rechnergestützte Modellierung im Bauingenieurwesen
Hours per Week / ECTS	4 / 6,0	**Module owner**	Henning Wessels
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			
Contents			
Objective qualification			
Literature			

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Henning Wessels		4	Lecture/Exercise	english

Data Science in Applications - Image and Signal Processing

Title	Mathematical Image Processing		
Number	1294300	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner's specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner's specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Interpolation and sampling, histograms
- Linear and Morphological filters

A selection from the following topics: frequency methods, sampling theorem, applications of partial differential equations or variational methods.

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture

- know and understand the characterization of the quality of an image through mathematical quantities
- know and understand the most important basic tasks in image processing and various methods of solving them

Literature

- Aubert, Kornprobst, Mathematical Problems in Image Processing, Springer, 2006
- Bredies, Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011
- Bernd Jähne, Digitale Bildverarbeitung, Springer 2005
- Gilles Aubert und Pierre Kornprobst, Mathematical Problems in Image Processing, Springer 2006
- Tony F. Chan und Jianghong Shen, Image Processing and Analysis: Variational, PDE, Wavelet and Stochastic Methods, SIAM, 2005

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dirk Lorenz		4	Lecture	english

Literature

- Aubert, Kornprobst, Mathematical Problems in Image Processing, Springer, 2006
- Bredies, Lorenz, Mathematische Bildverarbeitung, Vieweg, 2011
- Bernd Jähne, Digitale Bildverarbeitung, Springer 2005
- Gilles Aubert und Pierre Kornprobst, Mathematical Problems in Image Processing, Springer 2006
- Tony F. Chan und Jianghong Shen, Image Processing and Analysis: Variational, PDE, Wavelet and Stochastic Methods, SIAM, 2005

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dirk Lorenz		2	Exercise	english

Title	Information Theory and Signal Processing		
Number	1294320	**Module version**	V2
Shorttext	MAT-STD7-3	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	6 / 10,0	**Module owner**	Studiendekan der Mathematik
Workload (h)			
Class attendance (h)	84	**Self studying (h)**	216
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded examination (Prüfungsleistung): 1 written exam (120 minutes) or 1 oral exam (25-35 minutes) according to examiner’s specifications. After approval by the examination board mathematics (Prüfungsausschuss Mathematik), the examiner can also choose the take-home exam as the form of examination. The exact examination specifications will be announced at the beginning of the course.		
Course achievement	Non-graded coursework (Studienleistung): Homework according to examiner’s specifications. The exact examination specifications will be announced at the beginning of the course.		
Module grade composition			

Contents

- Basic concepts of coding theory
- Kraft inequality and McMillan's theorem,
- Independent identically distributed information sources and Huffman codes,
- Entropy and other basic concepts of probability theory,
- Stochastic processes and entropy rates,
- Shannon's theorem for independently identically distributed random variables,
- The Law of Large Numbers and the Equal Distribution Theorem,
- Universal coding and Lempel-Ziv coding,
- Rate Distortion Theory

Objective qualification

The students
- understand the of the complex links between their previous mathematical knowledge and the contents of the lecture
- understand the theoretical body of the lecture as a whole and master the corresponding methods
- are able to analyze and apply the methods of the lecture
- know and understand the optimal coding of random data sources
- know and understand the calculation of optimal codings with the help of the entropy rate of the associated stochastic process as a central variabl

Literature

- Thomas Cover, Joy Thomas: „Elements of Information Theory“, Wiley Series on Telecommunication

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Title	Deep Learning for imaging in nano and quantum science		
Number	1520500	**Module version**	
Shorttext	PHY-AP-50	**Language**	german
Frequency of offer	only in winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Uwe Rossow
Workload (h)	0		
Class attendance (h)	35	**Self studying (h)**	115
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			
Contents			
Objective qualification			
Literature			

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Deep Learning for imaging in nano and quantum science				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Etzkorn Andreas Hangleiter Uwe Rossow Uta Schlickum		3	Lecture	english

Name of the course				
Deep Learning for imaging in nano and quantum science				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Uwe Rossow		1	Exercise	english

Title	Network Information Theory		
Number	2424650	**Module version**	
Shorttext	ET-NT-65	**Language**	english
Frequency of offer	only in winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Eduard Jorswieck
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Written exam (90 min) or oral exam (30 min)		
Course achievement			
Module grade composition			

Contents

- Review point-to-point channel capacity and coding theorem
- Strong typical sequences and their properties
- Multiple-Access Channel: Capacity region compared to TDMA/FDMA/SDMA/NOMA
- #Broadcast Channel: degraded BC capacity region, non-degraded BC achievable rate region and converse
- Interference Channel: very strong, strong, weak interference capacity region, medium interference achievable rate region and converse
- #Relay Channel: achievable schemes amplify-and-forward, decode-and-forward, compress-and-forward, estimate-and-forward #Generalization and application of elements to complex networks

Objective qualification

After completing the lecture, the students will know the building blocks of complex communications networks, i.e., the multiple-access channel, the broadcast channel, the relay channel and the interference channel, their achievable rates and capacity regions including coding and decoding schemes. In addition, the students obtain knowledge to design future wireless and multi-hop as well as ad-hoc networks. They master information-theoretic and mathematical tools to prove coding theorems. They know the state of the art as well as open problems in network information theory.

Literature

#A. El Gamal and Y.-H. Kim: Network Information Theory, Cambridge University Press, 2011.
D. Tse and P. Viswanath: Fundamentals of Wireless Communications, Cambridge University Press, 2007.
T. M. Cover and J. A. Thomas: Elements of Information Theory, 2nd ed., New York: Wiley-Interscience, Juli 2006.
S. Boyd and L. Vandenberghe: Convex Optimization, Cambridge University Press, 2004.
R. W. Yeung: Information Theory and Network Coding, Part I, Springer, 2008.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Pin-Hsun Lin	Christian Deppe	2	Lecture	english
Literature				
A. El Gamal and Y.-H. Kim: Network Information Theory, Cambridge University Press, 2011 D. Tse and P. Viswanath: Fundamentals of Wireless Communications, Cambridge University Press, 2007 T. M. Cover and J. A. Thomas: Elements of Information Theory, 2nd ed., New York: Wiley-Interscience, Juli 2006 S. Boyd and L. Vandenberghe: Convex Optimization, Cambridge University Press, 2004 R. W. Yeung: Information Theory and Network Coding, Part I, Springer, 2008				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Pin-Hsun Lin	Christian Deppe	2	Exercise	english
Literature				
- A. El Gamal and Y.-H. Kim: Network Information Theory, Cambridge University Press, 2011. - D. Tse and P. Viswanath: Fundamentals of Wireless Communications, Cambridge University Press, 2007. - T.?M. Cover and J.?A. Thomas: Elements of Information Theory, 2nd ed., New York: Wiley-Interscience, Juli 2006. - S. Boyd and L. Vandenberghe: Convex Optimization, Cambridge University Press, 2004. - R.?W. Yeung: Information Theory and Network Coding, Part I, Springer, 2008.				

Title	Spoken Language Processing		
Number	2424680	**Module version**	
Shorttext	ET-NT-68	**Language**	german
Frequency of offer	only in winter term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	4 / 5,0	**Module owner**	Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Oral exam 30 minutes or written exam 90 minutes (depending on number of participants)		
Course achievement			
Module grade composition			

Contents

- Basics of speech production and perception
- Feature extraction
- Hidden Markov models
- Acoustic models and language models
- Automatic speech recognition
- Spoken language systems

Objective qualification

After successful completion of the module, students will be able to classify time series (e.g., speech signals) using hidden Markov modeling. The students acquire all the necessary knowledge to suitably select, design, and evaluate methods and algorithms for automatic speech recognition to solve problems in practice.

Literature

- Lecture slides
- X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001
- B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008
- A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004
- E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995
- G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003
- L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993
- K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990

Remark

This module from the master's program is also suitable for bachelor students. Basic knowledge of digital signal processing, as e.g. acquired in the module #digital signal processing#, facilitates the understanding of this lecture.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Timo Lohrenz		2	Lecture	english
Literature				
- Vorlesungsfolien - X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001 - B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008 - A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004 - E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995 - G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003 - L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993 - K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Timo Lohrenz		2	Seminar	english
Literature				
- Vorlesungsfolien - X. Huang, A. Acero, H.-W. Hon: Spoken Language Processing, Prentice Hall, 2001 - B. Pfister, T. Kaufmann: Sprachverarbeitung, Springer, 2008 - A. Wendemuth: Grundlagen der Stochastischen Sprachverarbeitung, Oldenbourg, 2004 - E.G. Schukat-Talamazzini: Automatische Spracherkennung, Vieweg, 1995 - G.A. Fink: Mustererkennung mit Markov-Modellen, Teubner, 2003 - L. Rabiner, B.-H. Juang: Fundamentals of Speech Recognition, Prentice Hall, 1993 - K. Fukunaga: Statistical Pattern Recognition, Academic Press, 1990				

Title	Fundamentals of Digital Signal Processing		
Number	2424760	**Module version**	
Shorttext	ET-NT-76	**Language**	german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Tim Fingscheidt
Workload (h)	150		
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents
Objective qualification
Literature
- Vorlesungsfolien - A.V. Oppenheim, R.W. Schafer, J.R. Buck: "Zeitdiskrete Signalverarbeitung" , Pearson Verlag, 2004 - K.D. Kammeyer, K. Kroschel: "Digitale Signalverarbeitung" , Teubner Verlag, 2002 - A.V. Oppenheim, R.W. Schafer, J.R. Buck: "`Discrete Time Signal Processing" , Prentice-Hall, 2004 - H.-W. Schüßler: "Digitale Signalverarbeitung 1" , Springer Verlag, 1994
Remark

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Marvin Sach Jan-Aike Termöhlen		2	Lecture	german
Literature				
A.V.Oppenheim, R.W.Schafer, J.R.Buck: Zeitdiskrete Signalverarbeitung, Pearson Studium, 2004 K.D.Kammeyer, K.Kroschel: Digitale Signalverarbeitung, Teubner Verlag, 2002 A.V.Oppenheim, R.W.Schafer, J.R.Buck: Discrete Time Signal Processing, Prentice Hall, 2004 H.-W.Schüßler: Digitale Signalverarbeitung, Springer Verlag, 1994				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Jan-Aike Termöhlen		1	Exercise	german
Literature				
siehe Vorlesung				

Title	Digital Signal Processing		
Number	2424770	**Module version**	
Shorttext	ET-NT-77	**Language**	german
Frequency of offer	only in summer term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	
Hours per Week / ECTS	5 / 8,0	**Module owner**	Tim Fingscheidt
Workload (h)	240		
Class attendance (h)	70	**Self studying (h)**	170
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents
Objective qualification
Literature
- Vorlesungsfolien - A.V. Oppenheim, R.W. Schafer, J.R. Buck: "Zeitdiskrete Signalverarbeitung" , Pearson Verlag, 2004 - K.D. Kammeyer, K. Kroschel: "Digitale Signalverarbeitung" , Teubner Verlag, 2002 - A.V. Oppenheim, R.W. Schafer, J.R. Buck: "`Discrete Time Signal Processing" , Prentice-Hall, 2004 - H.-W. Schüßler: "Digitale Signalverarbeitung 1" , Springer Verlag, 1994
Remark

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Marvin Sach Jan-Aike Termöhlen		2	Lecture	german
Literature				
A.V.Oppenheim, R.W.Schafer, J.R.Buck: Zeitdiskrete Signalverarbeitung, Pearson Studium, 2004 K.D.Kammeyer, K.Kroschel: Digitale Signalverarbeitung, Teubner Verlag, 2002 A.V.Oppenheim, R.W.Schafer, J.R.Buck: Discrete Time Signal Processing, Prentice Hall, 2004 H.-W.Schüßler: Digitale Signalverarbeitung, Springer Verlag, 1994				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Marvin Sach		2	Laboratory	german
Literature				
siehe Vorlesung				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Jan-Aike Termöhlen		1	Exercise	german
Literature				
siehe Vorlesung				

Title	Computer Vision and Machine Learning		
Number	4216330	**Module version**	V2
Shorttext	INF-CG-33	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Martin Eisemann
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	1 exam: written exam, 90 minutes or oral exam, 30 minutes		
Course achievement	1 study achievement: 50% of the exercises must be passed		
Module grade composition			

Contents

- Feature Detectors and Descriptors
- Object Detectio
- Matting
- Image Compositing and Editing
- Dense Correspondences
- Motion Capture
- Cameracalibration
- Epipolar Geometry
- Stereo and Multi-View Reconstruction
- Cameras and Scanner
- Machine Learning for Computer Vision Problems

Objective qualification

Upon successful completion of this module, students will have a basic understanding of how to develop complex computer vision applications. They are able to analyze computer vision problems and to design and implement appropriate solutions.

Literature

- Radke: Computer Vision for Multimedia, Cambridge University Press
- Szeliski: Computer Vision - Algorithms and Applications, Springer Verlag
- Goodfellow et al.: Deep Learning - Das umfassende Handbuch, mitp

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Computer Vision und Machine Learning				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Martin Eisemann		4	Lecture/Exercise	english
Literature				
- Radke: Computer Vision for Multimedia, Cambridge University Press - Szeliski: Computer Vision - Algorithms and Applications, Springer Verlag - Goodfellow et al.: Deep Learning - Das umfassende Handbuch, mitp				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Martin Eisemann		2	Exercise	english

Title	Biomedical Image and Signal Analysis		
Number	4217760	**Module version**	V2
Shorttext	INF-MI-76	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or experimental work or Portfolio		
Course achievement			
Module grade composition			

Contents

Using examples from ECG, X-ray imaging, magnetic resonance imaging and optical imaging systems we explain the general methods in medical signal and image processing. The methods are categorized according to their general properties, and the pros and cons of the manifold of methods is discussed using these categories. Systematic evaluation of signal and image analytics with and without ground truth is also addressed in this module.

Objective qualification

Passing this module, the students can classify and compare different methodologies for medical signal and image acquisition. They can differ and compare linear with non-linear filtering and analyze electrocardiography (ECG) data into their components. They can segment medical images in two and three dimensions and are able to apply model-based approaches for image and signal analytics.

Literature

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586.

- Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307.

- Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770.

- Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053.

- Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938.

- Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9.

- Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514.

- Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Medizin			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Biomedical Image and Signal Analysis				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Mostafa Haghi Nicolai Spicher		4	Lecture/Exercise	english
Literature				

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586. - Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307. - Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770. - Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053. - Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938. - Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9. - Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514. - Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		2	Exercise	german

Title	Deep Learning in Remote Sensing		
Number	4398860	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	
Module duration	1	**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 5,0	**Module owner**	Markus Gerke
Workload (h)	150 h		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements	As it is planned, the students should first take “Machine learning” or any similar course like “Pattern Recognition” in Winter semester and then “Deep learning in Remote Sensing” in Summer semester.		
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

In this module students are introduced to the concepts of deep learning in order to process Remote sensing data. Remote sensing is the science that provides geometric and semantic information about objects at or near the surface of the Earth using the sensors which are installed on satellites or other airborne platforms. Along with fundamentals of remote sensing, some applications like object detection and classification especially on images and also regression algorithms on remote sensing observations will be covered. In the context of image understanding, an introduction to digital image processing will be given, which deals with the application of filters on the images to extract the information which could be used in machine learning and deep learning algorithms. Each of the lectures in this module is supplemented by practical parts to enable the students to process real-world remote sensing datasets, efficiently. After completing the module, students know and understand the most important concepts of deep learning for image analysis. Furthermore, a student is able to implement a selection of algorithms and evaluate the respective result.

Objective qualification

Upon completion of this module, the students will be able to understand basic principles and applications of deep learning and to apply them on Remote Sensing as well as similar problems.

Literature

• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019.
• Pattern Recognition and Machine Learning, Bishop, C. M. 2006
• Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022
• Deep Learning, Goodfellow, Y. Bengio, and A. Courville, MIT Press, 2016
• Deep Learning for Remote Sensing Images with Open Source Software, Rémi Cresson, CRC Press, 2020.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
As it is planned, the students should first take “Machine learning” or any similar course like “Pattern Recognition” in Winter semester and then “Deep learning in Remote Sensing” in Summer semester.
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Exercise	english

Title			
Number	4398870	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in winter term	**Teaching unit**	
Module duration		**Institution**	Institut für Geodäsie und Photogrammetrie
Hours per Week / ECTS	4 / 5,0	**Module owner**	Markus Gerke
Workload (h)	150 h		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

This Module will introduce the fundamental methods at the core of machine learning, including -but not limited to- classification, regression analysis, clustering, and dimensionality reduction. This course is designed for BSc. and MSc. students in different disciplines who employ machine learning algorithms in their fields. Students will learn about the basic concepts of machine learning and will apply the learned concepts on the practical problems using open source libraries from the Python programming ecosystem. The course will also briefly cover neural networks and will be closed by a short introduction to deep learning. Classes on theoretical aspects will be complemented by practical lab sessions. In this course we do not concentrate on a specific type of data and various datasets will be used in the practical example.

Objective qualification

Upon completion of this module, the students will be able to understand basic principles and applications of machine learning and to apply them on practical examples.

Literature

• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019.
• Pattern Recognition and Machine Learning, Bishop, C. M. 2006
• Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022
Further information and material will be provided during the course.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Engineering			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi			Lecture	english
Literature				
• Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, 2019. • Pattern Recognition and Machine Learning, Bishop, C. M. 2006 • Machine Learning with PyTorch and Scikit-Learn, Sebastian Raschka, Yuxi (Hayden) Liu, Vahid Mirjalili, 2022 Further information and material will be provided during the course.				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Markus Gerke Mehdi Maboudi		2	Exercise	english

Title	Computer Lab Pattern Recognition		
Number	2424000020	**Module version**	
Shorttext		**Language**	english german
Frequency of offer	every term	**Teaching unit**	Fakultät für Elektrotechnik, Informationstechnik, Physik
Module duration	1	**Institution**	Institut für Nachrichtentechnik
Hours per Week / ECTS	4 / 5,0	**Module owner**	Tim Fingscheidt
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

The course consists of hands-on programming tasks that are solved by the participants and subsequently evaluated in a semi-automated way. In total, seven units from the sub-fields (i) basics of hands-on application of machine learning methods, (ii) image processing (computer vision) and (iii) time series analysis have to be completed. The seven units are:

- Interactive introduction to Python fundamentals using Jupyter notebooks, fundamentals of data processing, preparation and visualization.
- Use of single-layer machine learning models to solve a two-class problem: Support vector machines (based on libsvm) and neural networks. Splitting and use of datasets, application of appropriate metrics for evaluation, use of high-level machine learning libraries such as SciKit-Learn
- Use of deep neural networks to solve a multi-class classification problem, introduction to recognized academic datasets such as MNIST and CIFAR-10, introduction to the use of deep learning libraries PyTorch and Tensorflow, usage and adaptation of pre-trained models
- Use of convolutional neural networks to solve more challenging image processing problems such as semantic segmentation and depth estimation, use of regularization methods in training
- Use of diverse cost functions to optimize neural networks, implementation of generative models such as Generative Adversarial Networks (GANs)
- Use of recurrent neural networks to solve problems based on time series data, application of concepts for anomaly detection
- Use of recurrent neural networks for speech processing, e.g., for noise reduction, analysis of neural networks with respect to their complexity (FLOPs, number of parameters)

Six out of the seven units have to be successfully passed for the entire computer lab module to be passed, among these unit 4 (convolutional neural networks) and unit 7 (recurrent neural networks in speech processing).

Objective qualification

In this course, students acquire the competencies to independently select and apply appropriate machine learning and deep learning methods for complex problems. The students ...
- ... master the programming language Python as well as the basics of the deep learning libraries PyTorch and Tensorflow.
- ... evaluate the effectiveness of simple machine learning models and neuronal networks for classification and regression problems.
- ... evaluate the quality of deep learning models on appropriate data (sub)sets with meaningful metrics
- ... know and use different types of neural networks for problems in the areas of image processing, time series processing and generative problems
- ... know and use different strategies for data preprocessing and data augmentation
- ... know and use different training and regularization methods for the optimization of neural networks
- ... evaluate the complexity of a neural network on the basis of various parameters

Literature

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses

Rules for the choice of courses

Compulsory attendance

Name of the course

Computer Lab Pattern Recognition

Lecturer	Additional lecturers	SWS	Eventtype	Language
Tim Fingscheidt Marvin Klingner		3	Internship	english german

Literature

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

Name of the course				
Computer Lab Pattern Recognition				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Fingscheidt Marvin Klingner		1	Colloquium	english ger-man
Literature				

- Christopher M. Bishop, Nasser M. Nasrabadi, “Pattern Recognition and Machine Learning”, Springer 2006
- Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press 2016

Data Science in Applications - Biology, Chemistry and Pharma

Title	Immunmetabolism		
Number	1398590 Bio-BB 31	**Module version**	
Shorttext	BL-STD-67	**Language**	english german
Frequency of offer	only in summer term	**Teaching unit**	Fakultät für Lebenswissen-schaften
Module duration	1	**Institution**	
Hours per Week / ECTS	8 / 10,0	**Module owner**	Karsten Hiller
Workload (h)	300		
Class attendance (h)	112	**Self studying (h)**	188
Compulsory requirements	none		
Recommended requirements	none		
Expected performance/ Type of examination	- term paper - oral presentation		
Course achievement	Successful participation in the practical course and seminar		
Module grade composition			

Contents

The seminar gives an introduction into the metabolism of macrophages and how to analyze it by using isotope-labeling experiments and modeling. Especially the role of itaconic acid, ROS, NO and glutathione is discussed. Afterwards, different analytical methods for studying the Immunometabolism of different cell lines will be presented by the students. The students will plan themselves the workflow for the practical course to answer different biological questions. The students will present their work by using different presentation concepts (talk, poster, etc).
Practical course: Students will apply their theoretical knowledge to answer different biological questions by using the methods discussed in the seminar. The students will apply several methods, covering cell cultivation, metabolite extraction, seahorse measurements, GC-MS measurements and data analysis, metabolic flux analysis with stable isotopes, etc.

Objective qualification

After completing the module, students are able to
- explain the importance of the metabolism of immune cells during infection/inflammation
- apply modern analytical techniques, such as isotope labelling, mass spectrometry and metabolic flux analysis - evaluate and interpret GC-MS data.
- interpret the energy metabolism by means of respiration measurements.
- develop concepts for solving systems biology problems with the help of different methods.
- present and discuss scientific work
- discuss controversial scientific topics and questions

Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Biologie, Chemie und Pharmazie			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Karsten Hiller Kerstin Schmidt-Hohagen			Seminar	english german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Karsten Hiller Kerstin Schmidt-Hohagen			Practical exercise	english german

Title	CM-B-3 Elucidation and Modelling of Biological Structures		
Number	1498680	**Module version**	
Shorttext	CHE-STD2-6	**Language**	german
Frequency of offer		**Teaching unit**	Fakultät für Lebenswissen-schaften
Module duration		**Institution**	
Hours per Week / ECTS	0 / 8,0	**Module owner**	
Workload (h)	240		
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	oral or written exam+ (30% of the practical work mark are taken into account in the overall module mark)		
Course achievement	Practical work (marked)		
Module grade composition	Practical work (marked) oral or written exam+ (30% of the practical work mark are taken into account in the overall module mark)		

Contents

Lecture Biomolecular Modelling: Introduction to the basics of simulations of biomacromolecules - Born-Oppenheimer approximation, potential energy surface, basics of statistical thermodynamics, empirical force fields and their efficient implementation - geometry optimization, molecular dynamics methods, thermodynamic and static description of (bio)chemical processes, analysis of molecular dynamics simulations, calculation of free energies, multiscale simulation methods - implicit solvent models, coarse-grained models, hybrid QM/MM methods, quantum-chemical embedding methods.

Computer Lab: Use of force field programs, visualization of crystal structures, geometry optimization, molecular dynamics and normal mode analysis of polypeptides, simulation of (bio)molecules) with different computational methods and their analysis, analysis of dynamical and entropic effects.

Project Lab: Molecular Dynamics Simulations of Biomolecules.

Objective qualification

The students are familiar with modern methods for modelling the structure of biomacromolecules and for simulating their thermodynamic properties. The know empirical force field methods, methods for performing molecular dynamics simulations, as well as modern multicale simulation methods. The students are able to judge the applicability and the limitations of such methods, to choose suitable simulation methods for their own research projects and to perform, analyze, and evaluate molecular dynamics simulations.

Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Biologie, Chemie und Pharmazie			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Biomolecular Modelling				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		2	Lecture	english german

Name of the course				
Computer Lab Biomolecular Modelling				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		2	Exercise	english german

Name of the course				
Project Lab Biomolecular Modelling				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		2	Internship	english german

Title	CB-B-4 Theoretical Biophysical		
Number	1498690	**Module version**	
Shorttext	CHE-STD2-6	**Language**	german
Frequency of offer		**Teaching unit**	Fakultät für Lebenswissenschaften
Module duration		**Institution**	
Hours per Week / ECTS	0 / 8,0	**Module owner**	
Workload (h)	240		
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	oral or written exam+ (20% of the coursework and 20% of the practical work mark are taken into account in the overall module mark)		
Course achievement	Solve coursework problems (umarked) Practical work (marked)		
Module grade composition	Solve coursework problems (umarked) Practical work (marked) oral or written exam+ (20% of the coursework and 20% of the practical work mark are taken into account in the overall module mark)		

Contents

Lecture and Computer Lab Theoretical Spectroscopy: Time-dependent quantum mechanics, interaction of electromagnetic radiation with molecules, basics of Hartree-Fock and density-functional theory, quantum-chemical calculation of spectroscopic data (Infrared and Raman spectroscopy, UV/Vis spectroscopy, ESR and NMR, simulation of spectra.

*Lecture and Computer Lab Artificial Molecular Intelligence:*Molecular quantum mechanics in a nutshell: Hartree–Fock (HF) theory, post-HF methods, density functional theory; Molecular machine learning in a nutshell: molecular representations, deep learning and kernel methods, generative models, uncertainty quantification, active learning; Applications: structure–property relationships, chemical space exploration, molecular design.

Project Lab Theoretical Biophysical Chemistry: Introduction to scientific programming and in-depth study of selected quantum-chemical methods. Application of quantum-chemical methods that usually cannot be used as "black-box" methods in own independet projects.

Objective qualification

The students have aquired knowledge on modern methods of quantum chemistry. They are familiar with the foundations of important methods and possess an overview of commonly used quantum-chemical methods, their implementation in scientific software, and their use in chemistry. They are able to judge the applicability and the limits of different quantum-chemical methods and to use choose suitable methods for their own research projects, to perform quantum-chemical calculations and to analyse, evaluate, and assess their results.

Literature

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Biologie, Chemie und Pharmazie			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Theoretical Spectroscopy				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		3	Lecture	english german

Name of the course				
Computer Lab Theoretical Spectroscopy				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		1	Exercise	english german

Name of the course				
Artificial Molecular Intelligence				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jonny Proppe		3	Lecture	english german

Name of the course				
Computer Lab Artificial Molecular Intelligence				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jonny Proppe		1	Exercise	english german

Name of the course				
Advanced Quantum Chemistry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob		3	Lecture	english german

Name of the course				
Computer Lab Advanced Quantum Chemistry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
N.N. Dozent-Chemie Christoph Jacob		1	Exercise	english ger-man

Name of the course				
Project Lab Theoretical Biophysical Chemistry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob Jonny Proppe		2	Internship	english ger-man

Name of the course				
Project Lab Advanced Quantum Chemistry				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Christoph Jacob Jonny Proppe		2	Internship	english

Title	Introduction to Chemometrics for Pharmaceutical Engineers		
Number	4011130	**Module version**	
Shorttext	PHA-PC-13	**Language**	german
Frequency of offer	only in winter term	**Teaching unit**	Fakultät für Lebenswissenschaften
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	4 / 6,0	**Module owner**	Knut Baumann
Workload (h)	180 h		
Class attendance (h)	56 h	**Self studying (h)**	124 h
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			

Contents

Objective qualification

Literature

Henrion, Multivariate Datenanalyse: Methodik und Anwendung in der Chemie und Verwandten Gebieten, 2012
Brereton, Chemometrics: Data Analysis for the Laboratory and Chemical Plant, Wiley & Sons, 2003
Wehrens, Chemometrics with R: Multivariate Data Analysis in the Natural Sciences and Life Sciences (Use R), Springer, 2011
Hastie, Tibshirani, Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2. Aufl., 2011
Brereton, Chemometrics: Data Driven Extraction for Science, Wiley & Sons, 2. Ed., 2018

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Biologie, Chemie und Pharmazie			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Knut Baumann Thomas Dutschmann Matthias Stein		1	Internship	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Knut Baumann		2	Lecture	german

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Knut Baumann Thomas Dutschmann Matthias Stein		1	Exercise	german

Title	Network Biology		
Number	4217840	**Module version**	V2
Shorttext	INF-MI-84	**Language**	english
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Tim Kacprowski
Workload (h)			
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	written exam, 90 minutes, or oral exam, 30 minutes or Take-Home-Exam		
Course achievement	50% of exercises must be passed		
Module grade composition			

Contents

- Introduction graph theory
- Biological networks
- Biological network databases
- Statistical network analysis
- Graph algorithms
- Graph-based machine learning

Objective qualification

After successful completion of this module, students will
have a basic understanding of graph theory and its applications for the analysis of biomedical data. They will be able to use network biology tools and critically assess network analyses. They will be capable to devise new graph-based strategies for the analysis of biomedical data.

Literature

tba

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Biologie, Chemie und Pharmazie			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Network Biology				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Kacprowski	Simone Scharke	4	Lecture/Exercise	english
Literature				
to be announced				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Tim Kacprowski	Simone Scharke	2	Exercise	english

Data Science in Applications - Medicine

Title	Medical-methodological specialization module 1		
Number	4217720	**Module version**	V2
Shorttext	INF-MI-72	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: oral exam (30 minutes) or development and documentation of computer programs or Portfolio		
Course achievement			
Module grade composition			

Contents

The module focus on several examples, all taken from IT-supported clinical research and medical trials.

Objective qualification

Passing this module, the students develop a fundamental understanding for methodological aspects of medical informatics. They can plan and conduct scientific studies and can develop novel research projects in the field of electronic health. The students can use, compare, and evaluate specific IT tools in medical informatics. They know about data privacy and security issues for medical data in Europe.

Literature

- Roos-Pfeuffer, B.: Klinische Prüfung von Medizinprodukten: Ein Kommentar zu DIN EN ISO 14155. Beuth Verlag, 2015. ISBN-13: 978-3410241539

- Schumacher, M.: Methodik Klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung (Statistik und ihre Anwendungen). Springer Verlag, 2008. ISBN-13: 978-3540851356.

- Gaus, W., Chase, D.: Klinische Studien: Regelwerke, Strukturen, Dokumente, Daten. DVMD Verlag, 2008. ISBN-13: 978-3833472220

- Johner, C., Hölzer-Klüpfel, M., Wittorf, S.: Basiswissen Medizinische Software. Aus- und Weiterbildung zum Certified Professional for Medical Software. Dpunkt Verlag Heidelberg. 2. Auflage, 2015. ISBN-13: 978-3864902307.

- Schneider, UK: Sekundärnutzung klinischer Daten: Rechtliche Rahmenbedingungen. Medizinisch Wissenschaftliche Verlagsgesellschaft, 2015. ISBN-13: 978-3954661428.

- Jäschke, T. (Hrsg.): Datenschutz im Gesundheitswesen: Grundlagen, Konzepte, Umsetzung. Medizinisch Wissenschaftliche Verlagsgesellschaft, 2016. ISBN-13: 978-3954662210.

- IT-Reviewing Board der TMF (Hrsg.): IT-Infrastrukturen in der patientenorientierten Forschung. Aktueller Stand und Handlungsbedarf 2015. TMF, 2016. ISBN-13: 978-389838-7101.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno		4	Lecture/Exercise	german
Literature				
• Roos-Pfeuffer B. Klinische Prüfung von Medizinprodukten: Ein Kommentar zu DIN EN ISO 14155. Beuth Verlag, 2015, ISBN-10: 3410241531, ISBN-13: 978-3410241539 • Schumacher M. Methodik Klinischer Studien: Methodische Grundlagen der Planung, Durchführung und Auswertung (Statistik und ihre Anwendungen). Springer Verlag 2008, ISBN-10: 3540851356, ISBN-13: 978-3540851356 • Gaus W, Chase D. Klinische Studien: Regelwerke, Strukturen, Dokumente, Daten. DVMD Verlag 2008, ISBN-10: 3833472227, ISBN-13: 978-3833472220 • Johner C, Hölzer-Klüpfel M, Wittorf S. Basiswissen Medizinische Software. Aus- und Weiterbildung zum Certified Professional for Medical Softare. Dpunkt Verlag Heidelberg, 2. Auflage 2015; ISBN-13: 978-3864902307 • Schneider UK. Sekundärnutzung klinischer Daten: Rechtliche Rahmenbedingungen. Medizinisch Wissenschaftliche Verlagsgesellschaft 2015; ISBN-13: 978-3954661428 • Jäschke T. (Hrsg). Datenschutz im Gesundheitswesen: Grundlagen, Konzepte, Umsetzng. Medizinisch Wissenschaftliche Verlagsgesellschaft 2016; ISBN-13: 978-3954662210 • IT-Reviewing Board der TMF (Hrsg). IT-Infrastrukturen in der patientenorientierten Forschung. Aktueller Stand und Handlungsbedarf 2015. TMF 2016; ISBN-13: 978-389838-7101				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		2	Online-exercise	german

Title	Medical Methodology Course 2		
Number	4217730	**Module version**	V2
Shorttext	INF-MI-73	**Language**	english german
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	written exam (90 minutes) or oral exam (30 minutes) or Portfolio		
Course achievement			
Module grade composition			

Contents

The courses in this module vary from semester to semester. They are announced timely on the web page of PLRI.

Objective qualification

Passing this module, the students have earned a fundamental understanding of the methodological aspects of medical informatics. They can plan and conduct clinical trials and apply appropriate statistics to evaluate the recorded data. They can assess the systematics of scientific research in the broad biomedical field of applied computer science. They can compare IT tools for medical statistics and significance tests.

Literature

wird in der Lehrveranstaltung bekannt gegeben

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Smart Living				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Jonas Schwartze		3	Lecture/Exercise	english
Literature				
will be announced in the course				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		1	Exercise	english

Title	Accident Informatics		
Number	4217740	**Module version**	V2
Shorttext	INF-MI-74	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or Portfolio		
Course achievement			
Module grade composition			

Contents

- Selected aspects of eHealth and mHealth
- Relevant data formats, standards, and terminologies
- Existing systems in accident and emergency informatics
- Fundamentals to combine medical informatics and technical accident research

Objective qualification

Passing this module, the students can define the goals and perform a technical analysis of traffic accidents. The understand accident and emergency informatics on a more general level, and know the components of this novel field of research. They can use IT systems for accident research and build systems using appropriate data formats, standards, and protocols. Furthermore, they can construct scientific experiments in the field of accident and emergency informatics.

Literature

- Word Health Organization (WHO)(2016): Global diffusion of eHealth: Making universal health coverage achievable. WHO. ISBN-13: 978-92-4-151178-0; URL: http://www.who.int/goe/publications/ global_diffusion/en/

- Word Health Organization (WHO: Global Status Report on Road Safety 2015. WHO. ISBN-13: 978-9241565066, URL:
http://www.who.int/violence_injury_prevention/
road_safety_status/2015/en/

- Word Health Organization (WHO). Data Systems: A road safety manual for decision-makers and practitioners. WHO ISBN-13: 978-9241598965, URL: http://www.who.int/roadsafety/projects/ manuals/data/en/

- OECD (Ed)(2017): New Health Technologies: Managing Access, Value and Sustainability. OECD. ISBN-13: 978-9264266421.

- Johannsen, H.(2013): Unfallmechanik und Unfallrekonstruktion. Grundlagen der Unfallaufklärung. 3.Auflage. Springer-Vieweg. ISBN-13: 978-3658015930.

- Taschenmacher, R., Eifinger, W.(2014): Verkehrsunfallaufnahme. Unfallort – Tatort, Recht, Maßnahmen. 4. Auflage: Verlag Deutsche Polizeiliteratur. ISBN-13:978-3801106713.

- Ortlepp, J., Butterwegge. P.(2016): Unfalltypen-Katalog. Leitfaden zur Bestimmung des Unfalltyps. Neuauflage. Gesamtverband der deutschen Versicherungswirtschaft. URL: https://udv.de/download/file/fid/9308.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Nicolai Spicher		2	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Nicolai Spicher		2	Exercise	english

Title	Biomedical Image and Signal Analysis		
Number	4217760	**Module version**	V2
Shorttext	INF-MI-76	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or experimental work or Portfolio		
Course achievement			
Module grade composition			

Contents

Using examples from ECG, X-ray imaging, magnetic resonance imaging and optical imaging systems we explain the general methods in medical signal and image processing. The methods are categorized according to their general properties, and the pros and cons of the manifold of methods is discussed using these categories. Systematic evaluation of signal and image analytics with and without ground truth is also addressed in this module.

Objective qualification

Passing this module, the students can classify and compare different methodologies for medical signal and image acquisition. They can differ and compare linear with non-linear filtering and analyze electrocardiography (ECG) data into their components. They can segment medical images in two and three dimensions and are able to apply model-based approaches for image and signal analytics.

Literature

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586.

- Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307.

- Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770.

- Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053.

- Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938.

- Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9.

- Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514.

- Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Medizin			
Master Data Science PO 1	Data Science in Anwendungen - Bild- und Signalverarbeitung			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Biomedical Image and Signal Analysis				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Mostafa Haghi Nicolai Spicher		4	Lecture/Exercise	english
Literature				

- Lehmann, T.M., Oberschelp, W., Pelikan, E., Repges, R.(1997): Bildverarbeitung für die Medizin: Grundlagen, Modelle, Methoden, Anwendungen. Springer-Verlag, Berlin. ISBN-13: 978-3540614586. - Deserno, T.M.(Ed). (2011): Biomedical Image Processing. Springer-Verlag Berlin Heidelberg. ISBN-13: 978-3642267307. - Handels, H.(2009):Medizinische Bildverarbeitung: Bildanalyse, Mustererkennung und Visualisierung für die computergestützte ärztliche Diagnostik und Therapie. 2. Auflage. Vieweg & Teubner Verlag. ISBN-13: 978-3835100770. - Süße, H., Rodner, E.(2014): Bildverarbeitung und Objekterkennung: Computer Vision in Industrie und Medizin. Springer Vieweg. ISBN-13: 978-3834826053. - Dougherty, G.(2009): Digital Image Processing for Medical Applications. Cambridge University Press. ISBN-13: 978-0521181938. - Burger, W., Burge, M.J. (2015): Digitale Bildverarbeitung: Eine algorithmische Einführung mit Java.3. Auflage. Springer-Vieweg. ISBN-13: 978-3-642-04604-9. - Jähne, B.(2012): Digitale Bildverarbeitung und Bildgewinnung. 7. Auflage. Springer-Verlag Berlin. ISBN-13: 978-3642049514. - Broeke, J., Mateos Perez, J.M., Pascau, J.(2015): Image Processing with ImageJ. 2. Edition. Packt Publishing. ISBN-13: 978-1785889837.

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		2	Exercise	german

Title	Health-Enabling Technologies A		
Number	4217800	**Module version**	V2
Shorttext	INF-MI-80	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 6,0	**Module owner**	Thomas Deserno
Workload (h)	180		
Class attendance (h)	56	**Self studying (h)**	124
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam, 90 minutes, or oral exam, 30 minutes, or Portfolio		
Course achievement			
Module grade composition			

Contents

- Healthcare delivery with respect to specific diseases.
- Sensors and data analytics
- Architecture of appropriate information systems
- Evaluation and future perspectives of HET-based healthcare
- Ethical, regulatory and social aspects of HET

Objective qualification

Passing this module, the students are able to name different health enabling technologies (HET) and explain their ethical, regulatory and social aspects. The students can use methods and tools to build HET systems.

Literature

- Bardram JE, Mihailidis A, Wan D (Hrsg.). Pervasive Computing in Healthcare. Boca Raton, FL: CRC Press; 2006.

- Haux R, Koch S, Lovell NH, Marschollek M, Nakashima N, Wolf KH. Health-Enabling and Ambient Assistive Technologies: Past, Present, Future. Yearb Med Inform. 2016: S76-91.

- Öberg A, Togawa T, Francis A. Spelman FA (Hrsg.). Sensors in Medicine and Health Care (eBook). Weinheim: Wiley-VCH; 2006.

- van Hoof, J, Demiris, G, Wouters, EJM (Hrsg.). Handbook of Smart Homes, Health Care and Well-Being. Heidelberg: Springer: 2017.

- Ligges U. Programmieren mit R. Statistik und ihre Anwendungen. Springer-Verlag Berlin, 3. Auflage 2008; ISBN-10: 3540799974, ISBN-13: 978-3540799979

- Wollschläger D. Grundlagen der Datenanalyse mit R: Eine anwendungsorientierte Einführung. Springer-Verlag, Berlin, 3. Auflage 2015; ISBN-10: 3662455064, ISBN-13: 978-3662455067

- Beckerman AP, Childs DZ, Petchey OL. Getting Started with R: An Introduction for Biologists. Oxford University Press, 2. Edition 2017; ISBN-10: 0198787847, ISBN-13: 978-0198787846

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Health-enabling technologies A				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Leonie Heisig Ju Wang Joana Warnecke		4	Lecture/Exercise	english
Literature				
- Bardram JE, Mihailidis A, Wan D (Hrsg.). Pervasive Computing in Healthcare. Boca Raton, FL: CRC Press; 2006. - Haux R, Koch S, Lovell NH, Marschollek M, Nakashima N, Wolf KH. Health-Enabling and Ambient Assistive Technologies: Past, Present, Future. Yearb Med Inform. 2016: S76-91. - Öberg A, Togawa T, Francis A. Spelman FA (Hrsg.). Sensors in Medicine and Health Care (eBook). Weinheim: Wiley-VCH; 2006. - van Hoof, J, Demiris, G, Wouters, EJM (Hrsg.). Handbook of Smart Homes, Health Care and Well-Being. Heidelberg: Springer: 2017. - Ligges U. Programmieren mit R. Statistik und ihre Anwendungen. Springer-Verlag Berlin, 3. Auflage 2008; ISBN-10: 3540799974, ISBN-13: 978-3540799979 - Wollschläger D. Grundlagen der Datenanalyse mit R: Eine anwendungsorientierte Einführung. Springer-Verlag, Berlin, 3. Auflage 2015; ISBN-10: 3662455064, ISBN-13: 978-3662455067 - Beckerman AP, Childs DZ, Petchey OL. Getting Started with R: An Introduction for Biologists. Oxford University Press, 2. Edition 2017; ISBN-10: 0198787847, ISBN-13: 978-0198787846				

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Studiendekan der Informatik		2	Exercise	english

Title	Health-Enabling Technologies B		
Number	4217810	**Module version**	V2
Shorttext	INF-MI-81	**Language**	
Frequency of offer	only in summer term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Thomas Deserno
Workload (h)	150		
Class attendance (h)	56	**Self studying (h)**	94
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	graded work: written exam (90 minutes) or oral exam (30 minutes) or Portfolio		
Course achievement			
Module grade composition			

Contents

Plan and conduct appropriate experiments including the data analytics using different sensors for unobtrusive assessment of health-determining parameters.

Objective qualification

Passing this module, the students can explain and compare health enabling technologies (HET). This includes knowledge and practical use of HET applications, and its underlying scientific foundation. The students are able to build HET systems using recent technologies and can plan, conduct, and analyze experiments to evaluate HET technologies.

Literature

- Bardram, J.E., Mihailidis, A., Wan, D. (Hrsg.)(2006): Pervasive Computing in Healthcare. Boca Raton, FL: CRC Press.

- Haux, R., Koch, S., Lovell, N.H., Marschollek, M., Nakashima, N., Wolf, K.H.(2016): Health-Enabling and Ambient Assistive Technologies: Past, Present, Future. Yearb Med Inform. S.76-91.

- Öberg, A., Togawa, T., Francis, A., Spelman, F.A. (Hrsg.)(2006): Sensors in Medicine and Health Care (eBook). Weinheim: Wiley-VCH.

- van Hoof, J., Demiris, G., Wouters, E.J.M. (Hrsg.)(2007): Handbook of Smart Homes, Health Care and Well-Being. Heidelberg, Springer.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno		1	Lecture	english

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno		3	Exercise	english

Title	Selected Topics of Representation and Analysis of Medical Data		
Number	4217880	**Module version**	V2
Shorttext	INF-MI-88	**Language**	english german
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1	**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	written exam (90 minutes) or oral exam (30 minutes) or Portfolio or Take-Home-Exam		
Course achievement			
Module grade composition			

Contents

There is a rapid change in methodology and assessment of current techniques for medical data analytics, in particular using deep learning. Therefore, the content of this module reflects the actual technologies and will be announced shortly before the module starts.

Objective qualification

The students can recall recent trends and technologies to represent and analyze medical data. They are able to compare approaches and report their key characteristics resp. differences. They can construct tools and scientific methodologies for data modelling and analytics. The students recognize quality criterions and can recommend specific approaches.

Literature

IMIA Yearbook of Medical Informatics [erscheint jährlich]

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Data Science in Anwendungen - Medizin			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno	Thomas Deserno	3	Lecture/Exercise	english german

Data Science in Applications - Project Work

Title	Project Work Data Science		
Number	4299980	**Module version**	
Shorttext	INF-STD-98	**Language**	english
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 15,0	**Module owner**	
Workload (h)			
Class attendance (h)	14	**Self studying (h)**	436
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Software/program development and report on a data science project. Successful participation will be confirmed and graded by the supervisor. Graded project thesis (3 months processing time).		
Course achievement			
Module grade composition			

Contents
The teaching contents depend on the specific task and are partly taken from the project environment of the lecturer offering the course. They may vary on an annual basis.
Objective qualification
The project thesis can serve as preparation for the master's thesis. The students are able to use scientific methods systematically to solve a complex task in the area of data science. They are able to plan the work independently and estimate the work time required. They are able to carry out the project controlling and quality assurance e.g. using milestones which they have set for themselves.
Literature
Please ask your supervisor for current literature for your project thesis.

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Data Science in Anwendungen - Projektarbeit			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Key Qualifications and Ethics

Title	Data Privacy & Data Governance		
Number	2216010	**Module version**	
Shorttext		**Language**	english
Frequency of offer		**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	Dr. Anne Paschke
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	written exam, 60 minutes, or oral exam, 20 minutes, or term paper or Portfolio or Take-Home-Exam		
Course achievement			
Module grade composition			

Contents

Target is to develop a sensitivity when dealing with data especially if it is person related data. Henceforth the lecture progresses to Data Governance beyond personal data ownership. The students will learn how an organisation can control the use of data by internal regulations and provisions and how intra-organisational data exchange is shaped by standards. The students should develop a broad understanding of the importance of standards and interoperability. Furthermore the students will learn what it takes and what to consider before such a provision/standard is established whether inside an organisation or on intra-organisational level.

Objective qualification

The students understand the differences between the two main legal systems (case law vs. common law) in the EU. They know different sources of legal knowledge.
The students are able to assess company privacy regulations and business models in relation to the legal provisions.

Literature

A list of papers and videos will be provided in the first lecture.
Please see the LMS for further details.

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Schlüsselqualifikationen und Ethik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Master-Seminar Law (Civil Law)				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Dr. Anne Paschke		2	Lecture	german

Title	Key Qualifications		
Number	4298010	**Module version**	
Shorttext	INF-STD2-0	**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 5,0	**Module owner**	
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	An active performance record is required for the selected courses/modules (e.g. written examination, term paper, presentation, minutes). A certificate of attendance is not sufficient. The type of academic achievement depends on the module or course.		
Module grade composition			

Contents
Various in the elective courses of the overall program
Objective qualification
Superordinate reference/ embedding of the field of study Students will be able to classify their field of study in societal, historical, legal or professionally oriented references (depending on the focus of the course). They are able to recognize, analyze and evaluate higher-level, subject-related connections and their significance. The students acquire an insight into the networking possibilities of the field of study and application references of their field of study in professional life.
Literature
To be announced by the respective lecturers

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Schlüsselqualifikationen und Ethik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Title	Scientific Presentation and Writing		
Number	4298030	**Module version**	
Shorttext		**Language**	english
Frequency of offer	only in winter term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration	1 Semester	**Institution**	
Hours per Week / ECTS	3 / 5,0	**Module owner**	Tim Kacprowski
Workload (h)			
Class attendance (h)	42	**Self studying (h)**	108
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement	1 Presentation and elaboration (short article) on a research topic		
Module grade composition			

Contents

In the first part of the course, topics include structuring the text, appropriate wording, compre-hensibility of text, efficient production, review process and ethical aspects.

The second part addresses the creation of "good" visualizations. Students will learn about fun-damentals of perception, a proper mapping of data to visual variables, design principles, and visualization techniques and tools for specific types of data.

The third part covers oral presentations and scientific talks. Using their own research projects as well as other topics in exercises, students will practice and improve the delivery of their oral presentations.

Objective qualification

Students will learn the principles of scientific oral and written presentation and how to improve their talking according to the audience and their writing for successful publishing. They will be enabled to properly criticize existing visualizations and create new visualizations that are ef-fective, efficient, and appropriate.
They will also learn how to properly structure a talk, how to prepare adequate visual aids (“presentations”), and how oral presentations are different from written text.

Literature

1. Manual for Writers of Research Papers, Theses, and Dissertations: Chicago Style for Stu-dents and Researchers (Chicago Guides to Writing, Editing, and Publishing)

1.Englisch Ausgabe | von Wayne C. Booth, Gregory G. Colomb, et al. | 16. April 2018

2.BUGS in Writing, Revised Edition: A Guide to Debugging Your Prose Taschenbuch – 9. Februar 1998, Englisch Ausgabe von Lyn Dupre (Autor)

3.The Elements of Style. Englisch Ausgabe | von Jr. Strunk, William, E. White, et al. | 24. August 1999 4,6 von 5 Sternen 8.081

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Schlüsselqualifikationen und Ethik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Thomas Deserno Tim Kacprowski Steffen Oeltze-Jafra	Tim Kacprowski Simone Scharke		Lecture/Exercise	english

Title			
Number	4411440	**Module version**	
Shorttext	GE-Phil-44	**Language**	
Frequency of offer	only in winter term	**Teaching unit**	Fakultät für Geistes- und Erziehungswissenschaften
Module duration	1	**Institution**	
Hours per Week / ECTS	2 / 5,0	**Module owner**	Hans-Christoph Schmidt am Busch
Workload (h)	Präsenzzeit: 30 h Selbststudium: 120 h Gesamtworkload: 150 h		
Class attendance (h)		**Self studying (h)**	
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination			
Course achievement			
Module grade composition			
Contents			
Objective qualification			
Literature			
Anderson, Michael/Anderson, Susan Leigh (eds.): Machine Ethics, 2011 Misselhorn, Catrin: Grundfragen der Maschinenethik, 3rd ed. 2018 Nagel, Thomas: What is it like to be a Bat? Englisch/Deutsch, Reclam 2016			

Assigned to the following degree programs				
Degree program	**Area**	**Compulsory form**	**Semester**	**ECTS**
Master Data Science PO 1	Schlüsselqualifikationen und Ethik			

↑

Related courses
Rules for the choice of courses
Compulsory attendance

Name of the course				
Lecturer	**Additional lecturers**	**SWS**	**Eventtype**	**Language**
Nicole Karafyllis Hans-Christoph Schmidt am Busch		2		german
Literature				
Literature: Anderson, Michael/Anderson, Susan Leigh (eds.): Machine Ethics, 2011 Misselhorn, Catrin: Grundfragen der Maschinenethik, 3rd ed. 2018Nagel, Thomas: What is it like to be a Bat? Englisch/Deutsch, Reclam 201				

Master's Thesis	
ECTS	30

Title	Master's Thesis Data Science		
Number	4299970	**Module version**	
Shorttext	INF-STD-97	**Language**	german
Frequency of offer	every term	**Teaching unit**	Carl-Friedrich-Gauß-Fakultät
Module duration		**Institution**	
Hours per Week / ECTS	0 / 30,0	**Module owner**	
Workload (h)			
Class attendance (h)	1	**Self studying (h)**	899
Compulsory requirements			
Recommended requirements			
Expected performance/ Type of examination	Written thesis (final thesis) The presentation can be included in the evaluation with up to 3 of 30 credit points according to § 5 paragraph 7 (BPO)		
Course achievement			
Module grade composition			

Contents

The contents depend on the specific assignment.

Objective qualification

The students are able to work on a problem in the field of data science independently using scientific methods within a given time period.

The following points are particularly important:
- The student can familiarize themselves with the topic of the work independently.
- They can systematically work on a research problem relevant to data science using scientific methods.
- They are able to present the methods and the results in the form of an report.
- They present the main results in an understandable form in a presentation.
- They able to research literature and put their work into context.

Literature

Assigned to the following degree programs

Degree program	Area	Compulsory form	Semester	ECTS
Master Data Science PO 1	Masterarbeit			

↑

Related courses
Rules for the choice of courses
Compulsory attendance