Master of Science (M.Sc.)

"Mannheim Master in Data Science"

University of Mannheim

– Module catalog –

for students starting before autumn 2024

Academic Year HWS 2024/ FSS 2025

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Foreword

This document describes the courses that will be offered in HWS 2023/ FSS 2024 for students studying M. Sc. Mannheim Master in Data Science (Examination Regulations for the Master's program from 10th December 2019). You can find the Examination Regulations on the website of the Student Services (Studienbüros):

https://www.uni-mannheim.de/en/academics/during-your-studies/examinations/examination-regulations/

It is possible that additional courses will be made available during the course of the academic year. These will be published in an appendix available on the following web page:

https://www.wim.uni-mannheim.de/en/academics/organizing-your-studies/mannheim-master-indata-science/#c112237

A. Overview

		ECTS
Fundamentals	"Fundamentals" courses with at most 14 ECTS	0-14
Data Management	Minimum of three "Data Management" courses	18 – 36
Data Analytics Methods	Minimum of four "Data Analytics Methods" courses	30 – 54
Responsible Data Science	Minimum of one "Responsible Data Science" course	3 - 10
Projects and Seminars	Team Project or Individual Project, Scientific Research and Seminars	14 – 18
Master Thesis	Six-months-long written academic assignment	30
Total		120

General constraints:

- 1. Fundamental courses with 0-14 ECTS can be taken (0 to 14 ECTS)
- 2. 3 to 6 Data Management courses must be taken (18 to 36 ECTS)
- 3. Data Analytics Methods courses worth a combined 30 to 54 ECTS must be taken
- 4. 1 to 2 Responsible Data Science courses must be taken (3 to 10 ECTS)
- 5. You must either take a Team Project course or an Individual Project course
- 6. You must take Scientific Research
- 7. You must take a Seminar
- 8. You must write a Master Thesis

Abbreviations:

HWS (Herbst-/Wintersemester): Course is offered in the respective Fall semester.

FSS (Frühjahrs-/Sommersemester): Course is offered in the respective Spring semester.

FSS/HWS: course is offered both in Spring semester and Fall semester.

Course Structure



B. Fundamentals

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
CS 460	Databases for Data Scientists	FSS	Е	6	7
IS 557	Scientific Programming with Py- thon**	HWS	E	6	MMM*
DS 100	Statistics for Data Scientists	HWS	E	8	9

* For a detailed description, please see the module catalogues of the respective following degree programs:

- PW: B.A. Politikwissenschaft
 <u>https://www.sowi.uni-mannheim.de/en/academics/students/political-science/ba-in-political-science/</u>
- PS: M.A. Political Science
 <u>https://www.sowi.uni-mannheim.de/en/academics/students/political-science/ma-in-political-science/</u>
- MMM: M.Sc. Mannheim Master in Management
 <u>https://www.bwl.uni-mannheim.de/studium/master/mmm/</u>

**Prerequisites: No completed exam in CS 470 Programming with Python

2. Detailed descriptions

CS 460	Databases for Data Scientists	
Form of module	Lecture with Exercise	
Type of module	Foundations of Data Science (MMSDS) Fundamental (MMDS for students who started before 2024)	
Level	Master	
ECTS	6	
	Hours per semester present: 56 h (4 SWS)	
Workload	 Self-study per semester: 98 h 70 h: pre and post lecture studying and revision 28 h: examination preparation 	
Prerequisites	-	
Aim of module	 The course provides an introduction to data storage and dat base systems. The course will cover the following topics: Principles of data storage Relational modelling Query languages for relational databases (SQL) Keys and normal forms Hash and index structures Concurrency Databases for non-relational data Principles of data integration 	
Learning outcomes and qualification goals	Expertise: Basic understanding of data storage, relational data modelling and database design, as well as the functionality of relational database management systems, query handling, and transac- tion management. Handling non-relational data. (MK1, MK 2, MK3) Methodological competence: Abstraction, modelling, complexity consideration. (MF1, MF2) Personal competence: Understanding the role of data management in enterprises. (MK01, MK02)	

Media	Electronic slides and exercise sheets
Literature	Avi Silberschatz, Henry F. Korth, S. Sudarshan: Database System Concepts
Methods	The course consists of a lecture together and exercises. The ex- ercises encompass both theoretical exercises as well as practi- cal assignments, which are conducted with a free modern da- tabase management system and allow the students to deepen their theoretical understanding of the course contents, as well as to gather hands-on experience with database management systems.
Form of assessment	Written or oral examination
Admission requirements for assessment	-
Duration of assessment	60 minutes (written exam)/30 minutes (oral exam)
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Heiko Paulheim
Person in charge	Prof. Dr. Heiko Paulheim
Duration of module	1 semester
Further modules	Database Systems II, Large Scale Data Management, Web Data Integration
Range of application	MMSDS, MMDS (for students who started before HWS 2024)
Semester	1 st /2 nd semester

DS 100	Statistics for Data Scientists
Form of module	Lecture and Tutorial
Type of module	Foundations of Data Science
Level	Master
ECTS	8 (240 hours)
	Hours per semester present: 56 h (4 SWS)
Workload	 Self-study: 184 h per semester 84 h: pre and post lecture/tutorial studying and revision 35 h: studying for and taking weekly online tests 32 h: examination preparation 33 h: preparation and presentation of weekly exercises
Prerequisites	A sound understanding of the linear regression model (OLS) is required. Knowledge in linear algebra and calculus is useful.
Aim of module	 The course provides an introduction to causal inference, linear models, and maximum likelihood estimation. The course will cover the following topics: Causal Inference Hypotheses testing Linear Regression Selected GLM, e.g., binary choice models, models for ordinal data, models multinomial data, models for count data
Learning outcomes and qualification goals	Expertise (MK1, MK3): Understand how to appropriately translate research question into statistical models, be able to apply statistical models appro- priate for non-linear problems and learn how to present and in- terpret estimation results in a substantive meaningful way. Methodological competence (MK1, MK3): Estimate regression parameters using the maximum likelihood principle; Perform hypothesis tests for regression models using the maximum likelihood principle; Be able to identify violations of the respective regression assumptions of the discussed GLMs; Be able to identify limitations of non-linear regression models. Personal competence (MF1, MF2, MF3, MKO1, MKO2):

	The course supports students to develop competences with re- gard to choosing the appropriate statistical method(s) to an-		
	communicate statistical results.		
Media	Lecture slides available online, exercises available online		
Literature	 Cameron, C.A. and P.K. Trivedi. 1998. Regression Analysis of Count Data. Cambridge: Cambridge University Press. Greene, W.H. (2008). Econometric Analysis. 6th ed. Upper Saddle River: Prentice Hall. Long, J.S. (1997). Regression Models for Categorical and Limited Dependent Variables. Thousand Oaks: Sage. Verbeek, M. 2017. A Guide to Modern Econometrics. 5th ed. Chichester: Wiley. Wooldridge, J.M. 2002. Econometric Analysis of Cross Sec- tion and Panel Data. Cambridge, MA: MIT Press. Imbens, Guido W., and Donald B. Rubin. Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge: Cambridge University Press, 2015. Angrist, Joshua D., and Jorn-Steffen Pischke. Mostly Harm- less Econometrics: An Empiricist's Companion. Princeton: Princeton University Press, 2009. 		
Methods	Lecture elements, weekly online tests, literature studies		
Form of assessment	Written examination		
Admission requirements for assessment	Oral participation, homework, presentations, compulsory at- tendance		
Duration of assessment	90 Minutes		
Language	English		
Offering	Fall semester		
Lecturer	Lecturer of the School of Social Sciences, I.e chair of Social Data Science		
Person in charge	Lecturer of the School of Social Sciences, I.e. Chair of social Data Science		
Duration of module	1 semester		
Further modules			

Range of application	MMDS
Semester	1 st semester

C. Data Management

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 651	Additional Course – Data Manage- ment	HWS/FSS	E	Max. 18	13
CS 500	Advanced Software Engineering	HWS	Е	6	14
CS 550	Algorithmics	FSS	E	6	16
CS 560	Large Scale Data Management	HWS	E	6	19
CS 600	Model-driven Development	HWS	E	6	21
CS 651**	Cryptography II	HWS	E	6	23
CS 655**	Cryptography	FSS	E	6	25
CS 662**	Types and Programming Languages	FSS	E	6	27
CS 664**	Blockchain Security	HWS	E	6	29
CS 630**	Generative Software Engineering	FSS	E	6	31
IE 663	Information Retrieval and Web Search	HWS	E	3	33
IE 670	Web Data Integration	HWS	Е	3	35
IE 683	Web Data Integration Project	HWS	Е	3	37
IE 691	Information Retrieval Project	HWS	E	3	39
IS 540**	Management of Enterprise Systems	HWS	E	6	MMM*
IS 556**	Public Blockchains	FSS	E	6	MMM*
DS 200**	Sampling and Data	HWS	E	9	41
MAC 570**	Reinforcement Learning-Coding	Irreg.	E	8	43

* For a detailed description, please see the module catalogue of the respective following degree programs:

MMM: M.Sc. Mannheim Master in Management, <u>https://www.bwl.uni-mannheim.de/studium/mas-ter/mmm/</u>

**Additional offer to the Examination Regulations.

2. Detailed descriptions

AC 651	Additional Course – Data Management
Form of module	Depends on course
Level	Master
ECTS	Max. 18
Workload	Depends on course
Prerequisites	Depends on course
Aim of module	The course falls into the data management area of the MMDS and covers topics related to data management but is not di- rectly equivalent to any course in the MMDS module cata- logue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Meth- ods / Form and duration of assessment	Depends on course
Language	English preferred, but any other language possible if Mann- heim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	2 nd /3 rd /4 th semester

CS 500	Advanced Software Engineering (Software Testing and Experimentation)
Form of module	Lectures, exercises and tutorials
Type of module	Computer Science Fundamental
Level	Master
ECTS	6
	Hours per semester present: 56 h (2 + 2 SWS)
Workload	 Self-study: 112 h per semester 28 h per semester for preparation and studying of lectures/tutorials 84 h per semester for the preparation of the exams
Prerequisites	Knowledge of Java and/or Python
Aim of module	The course introduces the fundamental concepts and prac- tices of software testing, and software experimentation / eval- uation • Principles of Testing • Test Coverage Criteria • Test specification techniques • Model-based testing • Principles of Experimentation • Using Software Observatoriums
	Expertise: Students will be familiar with principles, approaches and tools for testing software and the methods and empirically evaluat- ing software products, methods and tools (MK1, MK2)
Learning outcomes and qualification goals	Methodological competence: Students will have the ability to judge, select, and apply tradi- tional or non-traditional test tools and techniques to evaluate software quality, as well as to design and perform software experiments. (MF1) (MF1, MF3) Personal competence: Students will have improved skills in analytical thinking and ap- plying theoretical knowledge to solve practical problems, es- pecially in software testing and experimentation.

	(МКОЗ)
Media	Lecture notes, presentations, tool demonstrations, software, data sets
Literature	• Paul Ammann & Jeff Offutt., "Introduction to Software Testing", Cambridge University Press, January 2008.
Methods	Lectures, weekly exercises, experimentation with different systems
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Dr. Marcus Kessel, Prof. Dr. Colin Atkinson
Person in charge	Prof. Dr. Colin Atkinson
Duration of module	1 Semester
Further modules	Model-Driven
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1 st or 2 nd semester

CS 550	Algorithmics
Form of module	Lecture with tutorials
Type of module	Fundamental in Computer Science
Level	Master
ECTS	6
	Attendance: 56 h per semester (4 h per week)
Workload	 Self-study: 112 h per semester 28 h per semester for preparation and reworking of lectures/tutorials 84 h per semester for the preparation of the exams
Prerequisites	Practical Informatics I, Algorithms and Data Structures, Linear Al- gebra, Statistics
Aim of module	 The lecture deals with the design and the analysis of algorithms for various practically relevant computational problems and with methods for analyzing the complexity of certain problems. In particular, we will learn methods of formalizing discrete optimization problems and designing algorithms for them on the basis of analyzing the structure of these problems. Moreover, we will learn techniques for proving the correctness and estimating the running time of these algorithms. In the second part of the lecture, we will deal with the theory of NP-completeness with gives evidence that certain highly relevant problems do not have efficient algorithms. During the lecture we will derive algorithms and complexity-theoretic results for the following computational problems: shortest path problems and shortest round tour problems flow problem matching problems satisfiability problems discret linear optimization problems
Learning outcomes and qualification goals	Professional expertise: The students know efficient algorithms and the most important complexity-theoretic results for a number of computational prob- lems which are highly relevant in practice. (MK1, MK2)

	Methodological competence: The students learn to formalize in- formally specified computational problems, to analyse their struc- ture with the goal to design efficient algorithms, to prove the cor- rectness and to analyse the running time of given algorithms. Moreover, they learn to prove the NP-completeness of certain problems. (MF1, MF3)
	Personal competence: Training of analytical, focussed and precise thinking. Further development of abstraction abilities and the ability to transfer theoretical knowledge for solving practical problems, especially in the field of operations research. Increas- ing the sensitivity for the complexity and the efficient solvability of computational problems, especially through dealing with the theory of NP-completeness. (MF1, MKO3)
Media	Writing with chalk at the blackboard, slides and electronic media
Literature	 Cormen, Leiserson, Rivest, Stein: Introduction to Algorithms, 3rd edition Shimon Even: Graph Algorithms Lovasz, Plummer: Matching Theory Handbooks on Operations Research and Management Science Volume 7 (Editors: Ball, Magnati, Monma, Nemhauser) J. Toran: Das Erfüllbarkeitsproblem SAT, Lehmann Media, 2012
Methods	Reworking of lectures and tutorials, self-studies with literature, solving exercises at home and in cooperation with other students at the tutorials
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 Minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Matthias Krause
Person in charge	Prof. Dr. Matthias Krause

Duration of module	1 semester
Further modules	CS 651 – Cryptography II
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Wirtschaftsmathematik, M.Sc. Wirtschaftspädagogik, Lehramt Informatik, M.Sc. Mathematik, MMDS, MMSDS
Semester	1./ 2. Semester

CS 560	Large-Scale Data Management
Form of module	Lecture with exercises
Type of module	Computer Science Fundamental
Level	Master
ECTS	6
Markland	In presence: 56 h (4 SWS)
WORKIOAU	Exercises and self-study: 98 h
Prerequisites	Very good knowledge of database systems, good knowledge of al- gorithms and data structures as well as Java programming
Aim of module	 This course introduces the fundamental concepts and computational paradigms of large-scale data management and Big Data. This includes methods for storing, updating, querying, and analyzing large dataset as well as for data-intensive computing. The course covers concept, algorithms, and system issues; accompanying exercises provide hands-on experience. Topics include: Parallel and distributed databases Big Data Processing (including MapReduce, Spark) NoSQL databases Cloud databases Stream processing (tentative) Graph processing (tentative)
Learning outcomes and qualification goals	Expertise: Students will acquire knowledge about methods and systems for managing large datasets and data-intensive computing. (MK1, MK2) Methodological competence: • Be able to judge, select, and use traditional or non-traditional
	 be using to judge, select, and use traditional of non-traditional data management systems for a given data management task Be able to solve computational problems involving large datasets (MF1)
	Personal competence:
	Study independently
	 Presentation and writing skills (MKO3)

Media	Slide set, black board, exercise sheets, datasets, software
Literature	 T. Öszu, P. Valduriez <i>Principles of Distributed Database Systems</i> Springer, 4th ed., 2020 H. Garcia-Molina, J. D. Ullman, J. Widom <i>Database Systems: The Complete Book</i> Prentice Hall, 2nd ed., 2008 More in lecture notes
Methods	Lecture, weekly exercise, experimentation with different systems
Form of assessment	Written examination
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Rainer Gemulla
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence, Lehramt Informatik
Semester	1 st / 2 nd semester

CS 600	Model Driven Development
Form of module	Lectures with accompanying tutorials
Type of module	Specialization course
Level	Master
ECTS	6
	Hours per semester present at university: 56 h (4 SWS)
Workload	 Self-study: 112 h semester 28 h: pre and post lecture studying and revision 56 h: tutorial exercises 28 h: directed independent study (reading papers, books etc.)
Prerequisites	 Software Testing and Experimentation
Aim of module	 The course focuses on the principles, practices and tools involved in advanced model-driven development. This includes estab- lished modelling standard languages (e. g. UML, ATL, OCL) and modelling infrastructures (e. g. MOF, EMF,) as well as leading edge, state-of-the-art modelling technologies (e. g. LML, PLM). Key topics addressed include: Principles of Model-Driven Development Meta-Modeling Domain-Specific Languages Model Constraint and Transformation languages Multi-View/Multi-Paradigm Modeling Ontology Modeling Enterprise Architecture Modeling
Learning outcomes and qualification goals	Expertise: Students will be familiar with the accepted best practices and technologies used in mainstream model-driven development as well as state-of-the-art modeling technologies emerging from re- search institutions. (MK1, MK2) Methodological competence: Students will know how to apply modeling technologies in real- world projects. (MF1, MF3)

	Personal competence: Students will have the capability to analyse, understand and
	model complex systems.
	(MKO1)
Media	Printed Lecture Notes, Presentations, Tool Demonstrations
Literature	• Jos B. Warmer and Anneke G. Kleppe, The Object Constraint Language: Getting Your Models Ready for MDA, Addison- Wesley Object Technology Series, 2003
Methods	Lectures, tutorials, independent study
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Colin Atkinson
Person in charge	Prof. Dr. Colin Atkinson
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	2 nd , 3 rd or 4 th semester

CS 651	Cryptography II
Form of module	Inverted classroom
Type of module	Specialization course
Level	Master
ECTS	6
	Hours per semester present: 56h (4 SWS) Self-study: 112h
Workload Prerequisites	Even though the lecture deepens and continues topics dis- cussed in <i>"CS 404 Cryptography I"</i> , it is not a prerequisite to have attended this lecture. The lecture <i>"Cryptography II"</i> can be studied without any prior knowledge on cryptography – all necessary basics are shortly recapitulated.
Aim of module	 The goal of this lecture is to present and discuss important scientific concepts from modern cryptography. This includes: Security Definitions: How can the security of cryptographic schemes formally defined? Proofs of Security: How can the security of cryptographic schemes be proven (based on precise assumptions)? Cryptanalysis: What are the established techniques to analyze cryptographic mechanisms? Elliptic Curves Zero-Knowledge Proofs
Learning outcomes and qualification goals	Expertise: With the help of current techniques and theories of modern cryptography, the students can assess the security of crypto- graphic processes and assess security statements accord- ingly. Furthermore, they can identify security goals and use appropriate techniques that could not be dealt with in "CS 404 Cryptography I". (MK2)
	Methodological competence: The students can select and use suitable methods for the se- curity analysis of cryptographic processes. This includes, for example, the choice of the appropriate security model, proof of security based on clearly specified assumptions and the analysis of given procedures. In particular, the students can understand and assess the security arguments for existing procedures and to transfer them to new ones. Furthermore, they can use techniques and protocols to achieve security goals that were not yet possible with the methods discussed in <i>"CS 404 Cryptography I"</i> . (MK1)

	Personal competence: The analytic, concentrated, and precise thinking of the students is trained. By the independent treatment of applications, e.g. in the course of the exercises, their abstraction capacity is further devel- oped and the transfer of the learned material to related questions is trained. (MF1, MKO3)
Media	Video recordings, annotated lecture slides
Literature	Jonathan Katz, Yehuda Lindell: Introduction to Modern Cryp- tography: Principles and Protocols, Chapman and Hall/CRC, 2007.
Methods	Reworking the lecture and studying the relevant literature in self-study. During the lecture: discussing questions and ideas and working together on concrete examples. Solving exer- cises in self-study and in practice in cooperation with fellow students.
Form of assessment	Oral exam
Admission requirements for assessment	none
Duration of assessment	30 minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Frederik Armknecht
Person in charge	Prof. Dr. Frederik Armknecht
Duration of module	One term
Further modules	none
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik, Lehramt Informatik, M.Sc. Mathematik
Semester	1st/2nd/3rd semester

CS 655	Cryptography
Form of Module	Lecture with Exercise
Type of Module	Specialization Course
Level	Master
ECTS	6
	Hours per semester present: 56 (4 SWS)
Workload	Self-study: 98h (70h lectures/exercises, 28h exam prepara- tion
Prerequisites	Basis skills in linear algebra, probability theory, algorithms, and data structures
Aim of Module	 Basic concepts of cryptography Mathematical Background Basics of Information Theory Block Ciphers (DES, AES, etc.) Stream Ciphers Secure Key Exchange Protocols (Diffie-Hellman protocol, etc.) Public Key encryption (RSA) Cryptographic Hash Functions Signature Systems and Message Authentication Codes Expertise: After the course the students are able to identify security ricks in various modern conparise of data traffic like online
Learning Outcomes and qualification goals	risks in various modern scenarios of data traffic like online banking, wireless communication, online trade (MK1) Methodological competence: The students are able to formulate and formalize security goals for various use cases and to choose and to ap- ply appropriate methods to reach these goals. Examples here are to provide data security data encryption, to estab- lish trusted electronical data encryption, to establish trusted electronical communication channels, or to apply methods for secure au- thentication (MF1)

	Personal competence:
	The course trains abstract thinking and the ability to
	formally model application scenarios. By solving exercises
	independently, the transfer of the learned material to
	related questions is promoted.
Media	Exercise sheets and lecture slides available online, blackboard
Literature	 Christof Paar, Bart Preneel, Jan Pelzl: Understanding Cryptography: A Terxtbook for Students and Practitioners, Springer 2009 Douglas R. Stinson: Cryptography - Theory and Practice, Taylor & Francis, 2005 Alan G. Konheim: Cryptography: A Primer, John Wiley & Sons, 1981
Methods	Lecture, exercises every two weeks, book studies
Form of assessment	Oral examination
Admission requirements for assessment	-
Duration of assessment	15 – 30 minutes
Language	English
Offering	FSS
Person in Charge	Prof. Dr. Matthias Krause
Duration of Module	1 Semester
Further Modules	Cryptography II
Range of Application	M.Sc Business Informatics, M.Sc Data Science, Lehramt In- formatik, B.Sc. Wirtschaftsmathematik
Semester	1 st /2 nd /3 rd Semester

CS 662	Types and Programming Languages
Form of module	Lecture with Exercise
Type of module	Specialization Course
Level	Master
ECTS	6
Markland	Hours per semester present: 56h (4 SWS)
vvorkioad	Self-study: 112h
Prerequisites	-
Aim of module	A type system is a syntactic method for enforcing levels of ab- straction in programs. The study of type systems—and of pro- gramming languages from a type-theoretic perspective—has im- portant applications in software engineering, language design, high-performance compilers, and security. In this lecture, we will discuss the following topics:
Learning outcomes and qualification goals	 Expertise: Get acquainted with the aims of the module (MK1, MK2, MF1, MF3) Methodological competence: Students will get familiar with the jargon used in scientific
	publications about programming languages
	(MF1, MF2, MF3)
	 Personal competence: Learn how to read scientific publications about programming languages Teamwork skills (MKO1, MKO2)
Media	Lecture slides, exercise sheets, project assignments, software, software documentation

Literature	<i>Types and Programming Languages</i> . February 2002. Benjamin C. Pierce. The MIT Press. ISBN: 978-0-262-16209-8
Methods	LectureWeekly Exercises/programming projects
Form of assessment	Written examination (90 minutes)
Admission requirements for assessment	\geq 50% points in homework assignments in groups of 2-3 students
Duration of assessment	90 minutes written exam
Language	English
Offering	FSS
Lecturer	Junior Professor Dr. Roland Leißa
Person in charge	Junior Professor Dr. Roland Leißa
Duration of module	1 semester
Further modules	-
Range of application	M. Sc. Wirtschaftsinformatik, Lehramt Informatik, MMDS, MMSDS
Semester	1st/2nd/3rd semester

CS 664	Blockchain Security
Form of module	Inverted classroom with exercises
Type of module	Specialization course
ECTS	6
Workload	Hours per semester present: 56h (4 SWS), Self-study: 112h
Prerequisites	There are no formal prerequisites but knowledge in cryptography and/or IT-security is recommended, e.g., by attending the lec- tures "Kryptographie I" or "Selected Topics in IT-Security"
Aim of module	Blockchains promise secure and reliable data storage and consen- sus in a trustless environment. In the light of their growing popu- larity, Blockchain security becomes increasingly important. The course will equip students with a solid understanding of block- chains, their design principles, underlying technologies and cryp- tographic primitives. Bitcoin, Monero and Ethereum will be dis- cussed in greater detail and a substantial part of the course will be devoted to security issues and possible attacks.
Learning outcomes and qualification goals	Expertise: Students will acquire profound knowledge of Blockchain technol- ogy as well as the skills to critically examine the security of Block- chain-based systems. (MK1, MK2)
	Methodological competence: Successful participants will be able to understand and evaluate the different ways in which different Blockchain systems try to achieve security. They will also be able to identify where, why and how these security measures are broken for both, current and new systems.
	(MKO3)
	Personal competence: The analytic, concentrated, and precise thinking of the students is trained. As multiple different but related Blockchains are dis- cussed, their abstraction capacity is further developed and the transfer of the learned concepts to related questions is trained. (MF1)
Media	Video recordings, annotated lecture slides
Literature	Will be announced in the lecture

Methods	Reworking the lecture and studying the relevant literature in self- study. During the lecture: discussing questions and ideas and working together on concrete examples. Solving exercises in self- study and in practice in cooperation with fellow students.
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	90 Minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Frederik Armknecht
Person in charge	Prof. Dr. Frederik Armknecht
Duration of Module	1 Semester
Further Modules	-
Range of application	MMDS, MMSDS, M.Sc. Wirtschaftsinformatik, Lehramt Informa- tik, M.Sc. Mathematik, M.Sc. Wirtschaftsmathematik
Semester	1st/2nd/3rd semester

CS 630	Generative Software Engineering
Form of module	Lectures, exercises and tutorials
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (2 + 2 SWS)
	 Self-study: 112 h per semester 28 h per semester for preparation and studying of lectures/tutorials 84 h per semester for the preparation of the exams
Prerequisites	Software Testing and ExperimentationKnowledge of Java and/or Python
Aim of module	The course introduces the fundamental principles, practices and applications of generative software engineering (GSE) as well as the supporting models, tools and services - • Software Recommendation and Reuse • Code Search Engines • Principles of GSE • Existing GSE models, tools and services • Defining GSE "problems" • Applications of GSE • Evaluation and comparison of GSE models, tools and services
Learning outcomes and qualification goals	Expertise: Students will be familiar with the principles, practices and ap- plications of GSE as well as supporting models, tools and ser- vices. (MK1, MK2)
	Methodological competence: Students will have the ability to judge, select, and apply GSE techniques and tools in practical software engineers, as well as the ability to understand academic GSE publications and to perform research in GSE. (MF1) (MF1, MF3)
	Personal competence: Students will have improved skills in analytical thinking and ap- plying theoretical knowledge to solve practical problems, es- pecially in the use of AI to enhance software engineering.

	(МКОЗ)
Media	Lecture notes, presentations, tool demonstrations, software, data sets
Literature	• Sommerville, Ian. "Software engineering (10th ed.).", Pearson Education Inc., 2018.
Methods	Lectures, weekly exercises, experimentation with different systems
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Spring semester
Lecturers	Dr. Marcus Kessel, Prof. Dr. Colin Atkinson
Person in charge	Prof. Dr. Colin Atkinson
Duration of module	1 Semester
Further modules	Model-Driven Development, Software Testing and Experimen- tation
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	2 nd , 3 rd or 4 th semester

IE 663	Information Retrieval and Web Search
Form of module	Lecture
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester present: 28h (2SWS)
	 Self-study: 60h per semester Pre- and post- lecture studying and preparation (30h) Examination preparation (30h)
Prerequisites	Fundamental notions of linear algebra, probability theory, as well as algorithms and data structures
Aim of module	 Given the vastness and richness of the Web, users need high-performing, scalable and efficient methods to access its wealth of information and satisfy their information needs. As such, being able to search and effectively retrieve relevant pieces of information from large text collections is a crucial task for the majority (if practically not all) of Web applications. In this course, we will explore a variety of basic and advanced techniques for text-based information retrieval and Web search. Covered topics will include: Efficient text indexing; Boolean and vector space retrieval models; Probabilistic and semantic ad-hoc retrieval; Evaluation of retrieval systems; Text classification and clustering; Web search, crawling and link-based algorithms. This course provides theoretical information retrieval foundations. As such is highly to be attended together with the course Informations.
Learning outcomes and qualification goals	Expertise: Students will acquire knowledge of fundamental techniques of In- formation Retrieval and Web Search, including standard retrieval models, evaluation of information retrieval systems, text classifica- tion and clustering, as well as web search topics such as crawling and link-based algorithms. (MK1, MK2, MF1)

	Methodological competence: Successful participants will be able to understand state-of-the-art methods for Information Retrieval and Web search, as well as be- ing able to select, apply and evaluate the most appropriate tech- niques for a variety of different search scenarios. (MF1, MF2, MF4)
	Personal competence: -
Media	Lecture slides, exercise sheets
Literature	 Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Addison-Wesley, 2009 R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Re- trieval, Addison-Wesley, 2011 (2nd Edition).
Methods	The course consists of (1) lectures that introduce the students to traditional and contemporary information retrieval techniques and models, and (2) exercises in which the students are demonstrated in terms of comprehensible examples how theoretically introduced models work.
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Simone Ponzetto
Person in charge	Prof. Dr. Simone Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Lehramt Informatik, MMDS, MMSDS
Semester	1 st /2 nd /3 rd semester

IE 670	Web Data Integration
Form of module	Lecture
Type of module	Specialization course
Level	Master
ECTS	3
	Hours per semester: 28 h (2 SWS)
Workloadk	 Self-study: 56 h per semester 31 h: pre and post lecture studying and revision 25 h: examination preparation
Prerequisites	-
Aim of module	Data integration is one of the key challenges in most IT projects and it is estimated that data scientists spend about 80% of their time on data integration and data preparation. Within the enter- prise context, data integration problems arise whenever data from separate sources needs to be combined as the basis for new appli- cations or data analysis projects. Within the context of the Web, data integration techniques form the foundation for taking ad- vantage of the ever-growing number of publicly-accessible data sources. The course will cover the following topics: 1. Heterogeneity and Distributedness 2. The Data Integration Process 3. Structured Data on the Web 4. Data Exchange Formats 5. Schema Mapping and Data Translation 6. Identity Resolution 7. Data Quality Assessment 8. Data Fusion It is highly recommended to attend the course web data integra- tion project in the same semester as this course as the schedules of both courses are aligned to each other.
Learning outcomes and qualification goals	 Expertise: Students will be able to identify opportunities for employing Web data in business applications and will learn to select and apply appropriate techniques for integrating and cleansing Web data. (MK1, MF1) Methodological competence: Participants will acquire knowledge of the data integration process as well as the techniques that are used in each phase of the process.
	(МК2, МF3, МF4, МКО3)

Media	slide set		
Literature	 AnHai Doan, Alon Halevy, Zachary Ives: Principles of Data Integration. Morgan Kaufmann, 2012. Luna Dong, Divesh Srivastava: Big Data Integration. Morgan & Claypool, 2015. Ulf Leser, Felix Naumann: Informationsintegration. Dpunkt Verlag, 2007. 		
Methods	The course consists of a lecture that introduces students to state of the art data integration techniques.		
Form of assessment	Written examination		
Admission requirements for assessment	-		
Duration of assessment	60 minutes		
Language	English		
Offering	Fall semester		
Lecturer	Prof. Dr. Christian Bizer		
Person in charge	Prof. Dr. Christian Bizer		
Duration of module	1 semester		
Further modules	-		
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence, Lehramt Informatik, MMSDS		
Semester	1 st /2 nd /3 rd semester		
IE 683	Web Data Integration Project		
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Form of module	Project		
Type of module	Specialization course		
Level	Master		
ECTS	3		
Workload	Hours per semester: 28 h (2 SWS)		
	 Self-study: 56 h per semester 36 h: project work 20 h: report writing and presentation preparation 		
Prerequisites	Programming skills in Java		
Aim of module	The web data integration project allows students to apply the methods and techniques that they have learned in the lecture Web Data Integration in the context of a practical integration project. The projects cover all steps of the data integration process includ- ing data gathering, schema mapping, data translation, identity res- olution, data quality assessment, and data fusion. It is highly recommended to attend the web data integration lec- ture in the same semester as the web data integration project as the schedules of both courses are aligned to each other.		
Learning outcomes and qualification goals	 Expertise: Students will be able to identify opportunities for employing Web data in business applications and will learn to apply appro- priate techniques for integrating and cleansing Web data. (MK1, MF1) 		
	 Methodological competence: Participants will acquire knowledge of the data integration process as well as the techniques that are used in each phase of the process. project organization skills		

Media	exercise sheets; Java project template		
Literature	 AnHai Doan, Alon Halevy, Zachary Ives: Principles of Data Integration. Morgan Kaufmann, 2012. Luna Dong, Divesh Srivastava: Big Data Integration. Morgan & Claypool, 2015. Ulf Leser, Felix Naumann: Informationsintegration. Dpunkt Verlag, 2007. 		
Methods	Students work on their integration projects in teams and will report about the results of their projects in the form of a written report as well as an oral presentation.		
Form of assessment	Project report (70%, 10-20 pages in length), oral project presenta- tion (30%, 20-30 minutes).		
Admission requirements for assessment	-		
Duration of assessment	4-6 weeks (execution of the project work and writing of the report), 20-30 minutes (presentation).		
Language	English		
Offering	Fall semester		
Lecturer	Prof. Dr. Christian Bizer		
Person in charge	Prof. Dr. Christian Bizer		
Duration of module	1 semester		
Further modules	-		
Range of application	M.Sc. Wirtschaftsinformatik, Lehramt Informatik, MMDS, MMSDS		
Semester	1. /2. /3. Semester		

IE 691	Information Retrieval Project	
Form of module	Project	
Type of module	Specialization course	
Level	Master	
ECTS	3	
	Hours per semester present: 28h (2SWS)	
Workload	 Self-study: 60h per semester Project work (45h) Report and presentation preparation (15h) 	
Prerequisites	Programming skills (preferably in one of the higher-level program- ming languages: Java/Python/C#/C++).	
Aim of module	Students are expected to successfully complete a team project in teams of 2-4 members. The projects will focus on a variety of IR problems and implementation of IR models theoretically covered in the course Information Retrieval and Web Search (IE 663). It is thus highly recommended to attend this course together with the course IE 663. Project deliverables include both software (i.e., code and documentation) and a short report explaining the work per- formed and its evaluation. The students are expected to clearly and coherently present the project results.	
	Expertise: Students will be able to solve real-world retrieval and search prob- lems: they will be able to analyze different potential solutions to a given problem, identify their advantages and shortcomings, and decide for the best solution. (MK1, MF1)	
Learning outcomes and qualification goals	Methodological competence: Students will obtain skills needed to implement one or more infor- mation retrieval models and test their usefulness on real-world problems. Successful participants will be able to fully understand state-of-the-art methods for Information Retrieval and Web search, through hands-on experience of implementing those mod- els. Students will also develop and/or improve their project organi- zation skills (activity planning, work breakdown, time planning, etc.) (MK2, MF3, MF4, MKO3) Personal competence:	
	Presentation skills	

	Team work skills
	(MKO2, MF2)
Media	Project task specifications
Literature	 Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Addison-Wesley, 2009 R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Re- trieval, Addison-Wesley, 2011 (2nd Edition).
Methods	Students work on implementing an information retrieval system in order to solve a real-worls search problem. Students work in teams, implement the programmatic solutions to the tasks, organ- ize their knowledge and results into a project report, and present the obtained results.
Form of assessment	Project report (70%, 10-20 pages in length), oral project presenta- tion (30%, 20-30 minutes).
Admission requirements for assessment	-
Duration of assessment	4-6 weeks (execution of the project work and writing of the report), 20-30 minutes (presentation).
Language	English
Offering	HWS
Lecturer	Prof. Dr. Simone Ponzetto
Person in charge	Prof. Dr. Simone Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Lehramt Informatik, MMDS, MMSDS
Semester	1 st /2 nd /3 rd semester

DS 200	Sampling and Data		
Form of module	Lecture and Tutorial		
Type of module	Data Science Methods: Fundamentals		
Level	Master		
ECTS	9 (270 hours)		
	Hours per semester present: 56 h (4 SWS)		
Workload	 Self-study: 214 h per semester 91 h: pre and post lecture studying and revision 42 h: studying for and taking weekly online tests 41 h: preparation and presentation of weekly exercises 40 h: examination preparation 		
Prerequisites	-		
Aim of module	The course introduces the most important social scientific forms of research and data collection methods, with a special focus on sampling methods.		
	Expertise: Students can independently formulate research questions and empirically verifiable hypotheses. (MK1)		
Learning outcomes and qualification goals	Methodological competence: Students know different data collection methods and their advantages and disadvantages; they are able to assess the appropriateness of the methods used to answer various questions; they understand and critically evaluate the design of empirical studies. (MK1)		
	Personal competence:		
	The course supports students to develop competences with regard to choosing the appropriate research design and sampling frame.		
Media	Lecture slides available online		
Literature	 Salganik, M. 2017. Bit by Bit: Social Research in the Digital Age. Princeton, NJ: Princeton University Press. 		

	 Foster et al. 2020. Big Data and Social Science: A Practical Guide to Methods and Tools. 2nd Edition. Boca Raton, FL: CRC Press. 			
Methods	Lecture elements, weekly online tests, literature studies			
Form of assessment	Written examination			
Admission requirements for assessment	Oral participation, homework, presentations, compulsory at- tendance			
Duration of assessment	90 Minutes			
Language	English			
Offering	Fall semester			
Lecturer	Lecturer of the School of Social Sciences, I.e. Chair of Social Data Science			
Person in charge	Lecturer of the School of Social Sciences, I.e. chair of Social Data Science			
Duration of module	1 semester			
Further modules				
Range of application	M.Sc. Mannheim Master in Data Science, M.Sc. Mannheim Master in Social Data Science			
Semester	1 st semester			

MAC 570	Reinforcement Learning - Coding	
Form of module	Lectures with exercises	
Type of module	Mathematics C	
Level	Master	
ECTS	5	
Workload	28 hours lectures 122 hours self-studies	
Prerequisites	Reinforcement Learning	
Aim of module	 Implementation of standard algorithms in reinforcement learning Bandit algorithms (UCB) TD algorithms (Q-learning, TD) Policy gradient algorithms (SAC, PPO) 	
Learning outcomes and	MK1, M02, M03	
qualification goals	MF1, MF3	
	(cf, "Erläuterungen zu den Abkürzungen")	
Media	Blackboard, Slides	
Literature	Original articles	
Methods	Lectures, programmig tasks	
Form of assessment	written exam	
Admission requirements for assessment	-	
Duration of assessment	90 min	
Language	English	
Offering	irregular	
Lecturer	Prof. Dr. Leif Döring	
Person in charge	Prof. Dr. Leif Döring	
Duration of module	1 semester	

Further modules	-
Range of application	M.Sc. Wirtschaftsmathematik, B.Sc. Wirtschaftsmathematik, M.Sc. Mathematik, M.Sc. Mannheim Master in Data Science, M.Sc. Wirtschaftsinformatik
Semester	1 st , 2 nd , 3 rd

D. Data Analytics Methods

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 652	Additional Course – Data Analytics Methods	HWS/FSS	E	Max. 18	48
DA 110	Computational Analysis of Communication	HWS/FSS	E	6	49
DS 202	Seminar and Lab on Machine Learning and Causal Infer-ence	HWS	E	9	51
IE 697	Data Science in Action	HWS	E	6	53
IE 500	Data Mining	HWS/FSS	E	6	55
IE 560	Decision Support	HWS	E	6	57
IS 661	Text Analytics	HWS	E	6	MMM*
IE 671	Web Mining	FSS	E	3	59
IE 675b	Machine Learning	HWS	E	9	61
IE 678	Deep Learning	FSS	E	6	63
IE 684	Web Mining Project	FSS	E	3	65
IE 686	Large Language Models and Agents	HWS	E	3	67
IE 692	Advanced Process Mining**	FSS	E	6	MMM*
IE 694	Artificial Intelligence Applications in Industry	FSS	E	6	69
IE 696	Advanced Methods in Text Analytics	FSS	E	6	71
IE 698	Foundations and Applications of Digital Health Technologies	FSS	E	3	73
IE 699	Co-creating digital health applica- tions with design methodology	FSS	E	6	75
IS 515	Process Management and Analytics	HWS	Е	6	MMM*
IS 616	Large Scale Data Analysis and Visu- alization	HWS	E	6	MMM*
IS 622	Network Science***	FSS	E	6	MMM*
MAA 519	Stochastic Calculus	HWS	E	5	MBE*
MAB 504	Mathematics and Information	irregular	G	8	MBE*
MAB 508	Algebraische Statistik	irregular	G/E	8	MBE*

MAB 519	Reinforcement Learning****	FSS	E	10	MBE*
MAB 520	Reinforcement Learning II	HWS	E	5	MBE*
MAC 404	Optimierung	HWS	G	8	WM*
MAC 502	Computational Finance	FSS	G/E	6	MBE*
MAC 507	Nichtlineare Optimierung	FSS	G/E	6	MBE*
MAC 527	Markov Processes	FSS	E	4	MBE*
MKT 511	Marketing Analytics	FSS	E	6	MMM*
MKT 545	Customers, Markets and Firm Strategy	FSS	E	6	MMM*
	Lecture Cross Sectional Data Analy- sis	HWS	E	6	Soc*
	Tutorial Cross Sectional Data Anal- ysis	HWS	E	3	Soc*
	Lecture Advanced Quantitative Methods	FSS	E	8	PS*
	Tutorial Advanced Quantitative Methods	FSS	E	2	PS*
	Lecture Longitudinal Data Analysis	FSS	Е	6	Soc*
	Tutorial Longitudinal Data Analysis	FSS	E	3	Soc*
	Lecture Research Design	HWS	E	6	Soc*
	Tutorial Research Design	HWS	E	3	Soc*
	Empirische Methoden der Poli- tikwissenschaft	HWS	G/E	6	PW*
CS 646	Higher Level Computer Vision	HWS	E	6	77
CS 647	Image Processing	HWS/FSS	Е	6	79
CS 668	Generative Computer Vision Mod- els	FSS	E	6	81
DS 201	Machine Learning and Causal Infer- ence	FSS	E	9	83

* For a detailed description, please see the module catalogues of the respective following degree programs:

- WM: B.Sc. Wirtschaftsmathematik
 <u>https://www.wim.uni-mannheim.de/studium/studienorganisation/b-sc-wirtschaftsmathematik/</u> (only
 available in German)
- MBE: M.Sc. Mathematics in Business and Economics
 <u>https://www.wim.uni-mannheim.de/studium/studienorganisation/m-sc-wirtschaftsmathematik/</u> (only
 available in German)
- PS: M.A. Political Science
 <u>https://www.sowi.uni-mannheim.de/studium/studierende/politikwissenschaft/ma-political-science/</u>
 (only available in German)

- Soc: M.A. Sociology
 <u>https://www.sowi.uni-mannheim.de/studium/studierende/soziologie/ma-sociology/</u>
- MMM: Mannheim Master in Management
 <u>https://www.bwl.uni-mannheim.de/studium/master/mmm/#c176637</u>
- **NOT offered in FSS 2025! The number of this module will change (TBA)
- ***Prerequisite: Not completed exam in IE 676
- ****Prerequisite: Not completed exam in IE 695

2. Detailed descriptions

AC 652	Additional Course – Data Analytics Methods			
Form of module	Depends on course			
Level	Master			
ECTS	Max. 18			
Workload	Depends on course			
Prerequisites	Depends on course			
Aim of module	The course falls into the data analytics methods area of the MMDS and covers topics related to data analytics methods but is not directly equivalent to any course in the MMDS module catalogue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.			
Learning outcomes and qualification goals	Depends on course			
Media / Literature / Meth- ods / Form and duration of assessment	Depends on course			
Language	English preferred, but any other language possible if Mann- heim faculty member is able to identify content and level			
Offering	Spring semester / Fall semester			
Lecturer	Lecturer at the host university			
Person in charge	Lecturer at the host university			
Duration of module	1 Semester			
Further modules	-			
Range of application	MMDS			
Semester	2 nd /3 rd /4 th semester			

DA 110	Computational Analysis of Communication	
Form of module	Exercise	
Type of module	Data Analytics Methods	
Level	Master	
ECTS	6	
Workload	Hours per semester present: 28 (2 SWS) Self-study: 145h (70h lectures/exercises, 75h research report)	
Prerequisites	Basic skills in descriptive and inferential statistics, basic knowledge of data structures and data wrangling procedures, machine learning, web-scraping/web-mining	
Aim of module	As "big data" and "algorithms" affect our daily communica- tion, new research questions arise at the intersection between societies and technologies. Many of these questions are of great social relevance and are therefore prominently dis- cussed both by researchers and in the media. One outstand- ing, recent example from the field of media psychology is a ris- ing interest in the association of (social) media use and mental health. Another example, from the realm of political commu- nication, is the ongoing debate about the role of new commu- nication technologies during political campaigns (e.g., to spread disinformation). Both questions revolve around the process of communication. Sound research in this area thus requires both a solid foundation from communication theory as well as expertise in handling new and "big" data. To close this gap, the growing discipline of Computational Communica- tion Science (CCS) takes on a combinatory perspective be- tween social and computer science. The present course will provide an overview about the current state of CCS and in- tends to motivate students to approach pressing social ques- tions from a different perspective.	
Learning outcomes and qualification goals	Expertise: After the course the students are aware of the typical research topics and questions in automated media content analyses and the different methodological approaches for tackling them; they know the different methods' potentials, limita- tions, and typical fields of application; they are able to develop their own specific research questions and can make an in- formed decision about which method to apply for answering it (MK3).	

	Methodological competence: Students are able to independently develop a research ques- tion and design in the area of automated media content anal- ysis and can conduct a respective analysis using one of the dif- ferent methodological ap-proaches introduced in the exercise; they are able to document the results of their analyses in a research report and reflect upon their find-ings' limitations with regards to reliability and validity. (MF1, MF2, MF3, MF4, MF5)
	Personal competence: The course supports students to develop problem-solving competences with regards to research-design oriented ques- tions. By solving exercises independently, the transfer of the learned material to related questions is promoted and self- confidence with regards to research-oriented tasks is gathered (MKO3).
Media	Exercise sheets and lecture slides are available online
Literature	van Atteveldt, W., Trilling, D., & Arcila, C. (2021). Computa- tional Analysis of Communication: A practical introduction to the analysis of texts, networks, and images with code exam- ples in Python and R. http://cssbook.net/
Methods	Lecture elements, student presentations, weekly exercises, literature studies
Form of assessment	Written research report (10 – 12 pages)
Admission requirements for assessment	-
Duration of assessment	4-8 weeks, depending on the topic
Language	English
Offering	HWS/FSS
Lecturer	МКЖ
Person in charge	МКЖ
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Data Science
Semester	1 st / 2 nd /3 rd semester

DS 202	Seminar and Lab on Machine Learning and Causal Inference
Form of module	Seminar
Type of module	Data Science Methods: Fundamentals
Level	Master
ECTS	9 (270 hours)
Workload	Hours per semester present: 56 h (4 SWS)
	 Self-study: h per semester 70 h: pre and post seminar studying and revision 70 h: analyzing data, programming Python scripts 74 h: preparation and presentation of research project
Prerequisites	Students should be familiar with Python or at least with any other object-programming language.
Aim of module	The module introduces, discusses, and offers hands-on expe- rience in state-of-the-art topics in data science. It consists of a "theoretical" part (seminar) which offers room for discus- sion on hot topics of data science and an "empirical" part where students formalize research questions and analyze data (of their own) using advanced techniques of machine learning.
Learning outcomes and qualification goals	Expertise: Students are able to find appropriate techniques of machine learning to answer complex research questions; they can an- alyze (large) data sets using state-of-the-art techniques of machine learning. (MK1)
	Methodological competence: Students are able to program in Python; they can apply ad- vanced techniques of machine learning to individual research questions; they have in-depth knowledge in application of data science. (MK1, MK2, MK3)
	Personal competence: Students are able to independently implement their research question in a research project; they can deal with and solve theoretical and empirical problems. (MF1, MF2, MF3, MF4, MKO1, MKO2)

Media	Slides available online
Literature	 Downey, Allen B. 2016. Think Python. How to Think Like a Computer Scientist. 2nd ed. Needham: Green Tea Press. (available online: http://greenteapress.com/thinkpy- thon2/thinkpython2.pdf) Guttag, John V. 2021. Introduction to Computation and Programming Using Python. 3rd. ed. Cambridge: MIT Press. The Python Tutorial (online: https://docs.py- thon.org/3/tutorial/)
Methods	Lecture elements, classroom discussion, weekly lab-sessions, literature studies
Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory at- tendance
Duration of assessment	90 Minutes
Language	English
Offering	Fall semester
Lecturer	Lecturer of the School of Social Sciences, I.e. chair of social data science
Person in charge	Lecturer of the School of Social Sciences, I.e. chair of social data science
Duration of module	1 semester
Further modules	
Range of application	MMSDS
Semester	3 rd semester

IE 697	Data Science in Action
Form of module	Lecture
Type of module	Elective
Level	Master
ECTS	6
Warkland	Hours per semester present: 28 h (2 SWS)
vvorkioad	Self-study: 112 h per semester
Prerequisites	Recommended: Knowledge in Data Mining, Machine Learn- ing, Statistics, or empirical research methods
Aim of module	Participants get insights in current Data Science Research in Computer Science as well as the economic and social sci- ences. The participants get an insight in the different per- spectives on Data Science present in different research com- munities.
	Expertise: Students will acquire knowledge of current research in Data Science (MK2, MK3)
Learning outcomes and qualification goals	Methodological competence: Students learn to understand and summarize the state of the art in a certain area and discuss achievements and open problems. (MF2, MKO2)
	Personal competence: -
Media	Slides, Research Papers
Literature	Recommended Papers from invited speakers
Methods	Lectures, independent study
Form of assessment	Written Essay
Admission requirements for assessment	-
Duration of assessment	4-6 weeks
Language	English

Offering	Fall semester
Lecturer	Prof. Dr. Heiner Stuckenschmidt, Invited Speakers
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 Semester
Further modules	-
Range of application	Mannheim Master in Data Science
Semester	24.

vith exercises and project Informatics Fundamental r semester: 56 h (4 SWS) y per semester: 98 h pre and post lecture studying and revision examination preparation
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ons of Statistics, Practical Informatics I
se provides an introduction to advanced data analy- ques as a basis for analyzing business data and giput for decision support systems. The course will following topics: and Principles of Data Mining Representation and Preprocessing fication er Analysis siation Analysis ical Data Mining using Python
: will acquire basic knowledge of the techniques, op- es, and applications of data mining. (MK1, MF1) logical competence: essful participants will be able to identify opportuni- or applying data mining in an enterprise environ-

Media	Slide set, exercise sheets, Jupyter notebooks, data sets for
	the exercises, lecture videos
Literature	• Pang-Ning Tan, Michael Steinback, Vipin Kumar: Introduc-
	tion to Data Mining, 2nd Edition, Pearson.
	Aurélien Géron: Hands-on Machine Learning with Scikit-
	Learn, Keras & TensorFlow, 3rd Edition, O'Reilly.
Methods	The course consists of a lecture together with accompanying practical exercises as well as student team projects. In the ex- ercises the participants will gather initial expertise in applying state of the art data mining tools on realistic data sets. The group projects take place in the last third of the term. Within
	the projects, students implement advanced data mining pro-
	jects of personal choice and report about the results of their
	projects in the form of a written report as well as an oral presentation.
Form of assessment	Written examination (75%), project report (20%), oral project
	presentation (5%)
Admission requirements for assessment	-
Duration of assessment	60 minutes (written examination), 5-11 pages (project re-
	port), 5-15 minutes (oral project presentation)
Language	English
Offering	Fall semester / Spring semester
Lecturer	Prof. Dr. Heiko Paulheim; Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Heiko Paulheim; Prof. Dr. Christian Bizer
Duration of module	1 Semester
Further modules	IE 675b – Machine Learning, IE 678 – Deep Learning, IS 661 – Text Analytics, CS 646 – Higher Level Computer Vi- sion, IE 671 – Web Mining
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1 st /2 nd semester

IE 560	Decision Support
Form of module	Inverted classroom
Type of module	Business Informatics Fundamental
Level	Master
ECTS	6
	Hours per semester: 42 h (1+2 SWS)
Workload	 Self-study per semester: 138 h 89 h: pre- and post lecture studying and revision 49 h: exam preparation
Prerequisites	Basic Probability Theory, Basic Knowledge of Propositional and First-Order Logic
Aim of module	 The course provides an introduction to decision support techniques as a basis for the design of decision support systems. The course will cover the following topics: Decision Theory Decision- and Business Rules Probabilistic Graphical Models Game Theory and Mechanism Design Decision Processes and Reinforcement Learning
	Expertise: Students will acquire basic knowledge of the techniques, opportu- nities and applications of decision theory.
Learning outcomes and qualification goals	(MK1, MF1) Methodological competence: Successful participants will be able to identify opportunities for de- cision support in an enterprise environment, select and apply ap- propriate techniques, and interpret the results. (MK2, MF3, MF4, MKO1) Personal competence: -
Media	Lecture videos, slide set, exercise sheets, software tools
Literature	 S. Russel and P. Norvig: AI a modern Approach (3rd Edition), 2010 (selected sections)
Methods	The course consists of a lecture accompanied by practical home- work and case studies. In the lecture, the students basic concepts

	and methods of decision theory will be explained both in theory and using concrete examples. The students will practice and test their knowledge acquired in the lecture in homework assignments. Within the case studies, students model real world decision prob- lems and try to solve them optimally using methods from the lec- ture.
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	Written examination: 90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science,
Semester	1 st /2 nd semester

IE 671	Web Mining
Form of module	Lecture and Exercise
Type of module	Specialization course
Level	Master
ECTS	3
Workload	Hours per semester: 28 h (2 SWS)
	 Self-study: 56 h per semester 31 h: pre and post lecture studying and revision 25 h: examination and presentation preparation
Prerequisites	IE 500 Data Mining I (recommended). Fundamental notions of lin- ear algebra and probability theory.
Aim of module	The vast amounts of textual content and structured data found on the Web provide us with a goldmine of data that can be mined to derive knowledge about nearly every aspect of human life. The course covers techniques for extracting knowledge from Web con- tent as a basis for business decisions and applications. The course will cover the following topics: Web Usage Mining (including Rec- ommender Systems), Web Structure Mining (including Social Net- work Analysis), and Web Content Mining (including Sentiment Analysis and Hate Speech Detection).
	ing Project" in the same semester since the schedule and topics of both modules are aligned.
Learning outcomes and qualification goals	Expertise: Students will acquire knowledge of the techniques, opportunities and applications of Web mining. (MK1, MF1)
	Methodological competence: Successful participants will be able to identify opportunities for mining knowledge from Web content, select and apply appropriate techniques and interpret the results. (MK2, MF3, MF4)
	Personal competence: -
Media	slide set, exercise sheets, data sets for the exercises
Literature	 Bing Liu: Web Data Mining. 2nd Edition, Springer, 2011. Wouter de Nooy, et al.: Exploratory Social Network Analysis with Pajek. 2nd Edition, Cambridge University Press, 2011.

	Bing Liu. Sentiment Analysis and Opinion Mining, Morgan & Claypool Publishers, 2012.
Methods	The course consists of a lecture together with accompanying prac- tical exercises as well as student team projects. In the exercises the participants will gather initial expertise in applying state of the art web mining tools.
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	60 minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik, MMSDS
Semester	1 st /2 nd /3 rd semester

IE 675b	Machine Learning
Form of module	Lecture with exercises
Type of module	Specialization Course
Level	Master
ECTS	9
Workload	In presence: 56 h (4 SWS)
	Exercises, assignments, and self-study: 174 h
Prerequisites	IE 500 Data Mining I (recommended), knowledge of probability and statistics, no attempted or completed IE 675 exam
Aim of module	 Machine learning is concerned with building computer systems that improve with experience as well as the study of learning processes, including the design of algorithms that are able to make predictions or extract knowledge from data. The aim of this module is to provide an introduction into the field of machine learning, and study algorithms, underlying concepts, and theoretical principles. Topics include: Basics of machine learning Inference and decision Selected classification and regression models Dimensionality reduction Mixture models and EM Kernels and vector machines Hyperparameter optimization
	Expertise: Deep understanding of algorithms and underlying concepts of ma- chine learning (MK1, MF1)
Learning outcomes and qualification goals	 Methodological competence: Being able to apply machine learning techniques and systems for a given problem Being able to model and implement new machine learning techniques (MK2, MF3, MF4)
	Personal competence:writing skillspresentation skills

	statistical programming skills
	(MKO3, MF2)
Media	Slide set, exercise sheets, software, datasets
Literature	 K.P. Murphy. <i>Probabilistic Machine Learning: An Introduction</i>. The MIT Press, 2022 I. Goodfellow, Y. Bengio, A. Courville. <i>Deep Learning</i>, The MIT Press, 2017 Additional material and articles provided in lecture notes
Methods	The course consists of a lecture accompanied by theoretical and practical exercises as well as case studies with real data. In the ex- ercises, students will deepen the material discussed in the lecture, apply the methods in practice, and present the result.
Form of assessment	Written examination
Admission requirements for assessment	Homework assignments (pass at least 3 assignments)
Duration of assessment	90 minutes
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Rainer Gemulla
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	1 st /2 nd /3 rd semester

IE 678	Deep Learning
Form of module	Lecture with exercises
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester: 56h (4 SWS)
Workidad	Exercises, assignments, and self-study: 98 h
Prerequisites	IE 675b Machine Learning or equivalent, no attempted or com- pleted IE 674 exam
Aim of module	 Machine learning is concerned with building computer systems that improve with experience as well as the study of learning processes, including the design of algorithms that are able to make predictions or extract knowledge from data. Building upon IE 675b Machine Learning, this course focuses on deep learning and introduces basic and advanced deep learning architectures and techniques, training methods and hyperparameter optimization, as well as selected applications. Topics include: Feedforward neural networks Backpropagation and parameter optimization Machine learning systems Training techniques for deep learning models Recurrent neural networks Attention and Transformers Deep learning for graphs Deep generative modelling
Learning outcomes and qualification goals	Expertise: Deep understanding of fundamental concepts, models, and algo- rithms of deep learning (MK1, MF1)
	Vietnodological competence:
	 Deing able to build and train deep learning models Being able to select suitable deep learning techniques for a
	given learning problem
	(MK2, MF3, MF4)
	Personal competence:

	writing skills
	presentation skills
	statistical programming skills
	(MKO3, MF2)
Media	Slide set, exercise sheets, software, datasets
Literature	 I. Drori. <i>The Science of Deep Learning</i>. Cambridge University Press, 2023 I. Goodfellow, Y. Bengio, A. Courville. <i>Deep Learning</i>, The MIT Press, 2017 K.P. Murphy. <i>Probabilistic Machine Learning: An Introduction</i>. The MIT Press, 2022 K.P. Murphy. <i>Probabilistic Machine Learning: Advanced</i> <i>Topics</i>. The MIT Press, 2023 Additional material and articles provided in lecture notes
Methods	The course consists of a lecture accompanied by theoretical and practical exercises as well as case studies with real data. In the ex- ercises, students will deepen the material discussed in the lecture, apply the methods in practice, and present the result.
Form of assessment	Oral examination
Admission requirements for assessment	Homework assignments (pass at least 2 assignments)
Duration of assessment	25 minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Rainer Gemulla
Person in charge	Prof. Dr. Rainer Gemulla
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	2 nd /3 rd semester

IE 684	Web Mining Project
Form of module	Project
Type of module	Specialization course
Level	Master
ECTS	3
	Hours per semester: 28 h (2 SWS)
Workload	 Self-study: 56 h per semester 36 h: project work 20 h: report writing and presentation preparation
Prerequisites	Programming skills in Java or Python. IE 671 Web Mining (recom- mended).
Aim of module	The Web Mining project allows students to apply the methods and techniques that they have learned in the lecture Web Mining in the context of a practical integration project. The projects can cover any of the topic of Web usage, content or structure mining.
	Mining" in the same semester since the schedule and topics of both modules are aligned.
Learning outcomes and qualification goals	 Expertise: Students will be able to identify opportunities for employing Web Mining techniques in business applications and will learn to apply appropriate techniques for mining Web data. (MK1, MF1)
	 Methodological competence: Participants will acquire practical knowledge of techniques for mining Web data. Project organization skills
	(MK2, MF3, MF4, MKO3)
	 Personal competence: Presentation skills Team work skills
	(MKO2, MF2)
Media	Slide set with references to potential topics, datasets, etc.
Literature	 Bing Liu: Web Data Mining. 2nd Edition, Springer, 2011. Wouter de Nooy, et al.: Exploratory Social Network Analysis with Pajek. 2nd Edition, Cambridge University Press, 2011. Bing Liu. Sentiment Analysis and Opinion Mining, Morgan & Claypool Publishers, 2012.

Methods	Students work on their projects in teams and report about the re- sults of their projects in the form of a written report as well as an oral presentation.
Form of assessment	Project report (70%, 5-15 pages in length), oral project presenta- tion (30%, 10-90 minutes).
Admission requirements for assessment	-
Duration of assessment	4-6 weeks (execution of the project work and writing of the report), 10-90 minutes (presentation).
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Christian Bizer
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Mannheim Master in Data Science Lehramt Informatik, MMSDS
Semester	1. /2. /3. Semester

IE 686	Large Language Models and Agents
Form of module	Lectures with tutorials and projects
Type of module	Specialization course
Level	Master
ECTS	3
Workload	 Hours per semester: 28 h (2 SWS) Self-study: 56 h per semester 36 h: project work 20 h: report writing and presentation preparation
Prerequisites	 Programming skills in Python Basic machine learning concepts and techniques
Aim of module	Large language models (LLMs) such as GPT, Llama, Gemini, and Mixtral have the potential to enable a wide range of new applica- tions and to significantly improve the performance of existing sys- tems. The course introduces students to LLMs and teaches them how to employ the models within applications. The course covers the following topics: Introduction to LLMs Prompt engineering patterns LLM-based agents Evaluation of LLMs and agents Development of LLM-based applications
Learning outcomes and qualification goals	Expertise: Students will understand the principles of training LLMs. They will be able to identify opportunities for employing LLMs in business applications and will learn to apply prompt engineering techniques as well as agent frameworks for solving business tasks. (MK1, MF1) Methodological competence: Participants will acquire theoretical and practical knowledge on large language models, prompt engineering techniques, and agents. They will learn to use frameworks like LangChain and Auto- Gen for the design and implementation of the learned concepts in practical use cases. (MK2, MF3, MF4, MKO3) Personal competence:

	 Project organization skills Presentation skills Teamwork skills Python programming skills (MKO1, MKO2, MF2)
Media	Slide sets, software, datasets
Literature	 Zhou et al.: A Comprehensive Survey on Pretrained Foundation Models: A History from BERT to ChatGPT. 2023. arXiv:2302.09419. Zhao et al.: A Survey of Large Language Models. 2024. arXiv:2303.18223 Wang et al.: A Survey on Large Language Model based Au- tonomous Agents. 2024. arXiv:2302.07842
Methods	The course participants gain knowledge about the principles and methods behind large language models through lectures and tuto- rials. In the second half of the course, students apply their knowledge in team projects and will report about their results in the form of a written report as well as an oral presentation.
Form of assessment	Project report (70%), oral project presentation (30%)
Admission requirements for assessment	-
Duration of assessment	-
Language	English
Offering	Fall semester
Lecturer	Prof. Dr. Christian Bizer Ralph Peeters
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Mannheim Master in Social Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

IE 694	Artificial Intelligence Applications in Industry
Form of module	Lectures and Accompanying Tutorials
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester present: 56 h (2 + 2 SWS)
	Self-study: 124 h per semester Including the creation of a learning portfolio
Prerequisites	Necessary Knowledge:Machine Learning Concepts and TechniquesProgramming in Python
Aim of module	Participants will learn about the use of Artificial Intelligence meth- ods, mostly from the field of machine learning in different sectors and industries. They will learn about application areas in the pri- mary, secondary and tertiary sector, get an introduction to exam- ples of such applications that have been published on a scientific level and gather some experience in working with data from the re- spective fields using publically available datasets.
Learning outcomes and qualification goals	Expertise: Students will acquire knowledge about possible applications of ma- chine learning in different branches of industry as well as the domi- nant methods used in these areas. (MK2, MK3)
	 Methodological competence: Successful participants will be able to: Identify potential for applying AI methods in different areas of industry; Decide on a suitable method for addressing typical problems in these industries (MF2)
	Personal competence:
	 Participants will learn to reflect and document their own learn- ing process
	(МКО2)
Media	Slides, Data Sets, Software Tools.

Literature	Various Scientific Publications – details in the lecture slides
Methods	Lectures, tutorials, independent study
Form of assessment	Learning Portfolio
Admission requirements for assessment	n/a
Duration of assessment	Continuous assessment throughout the module (learning portfo- lio).
Language	English
Offering	FSS
Lecturer	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, Mannheim Master in Data Science, MMSDS
Semester	24.

IE 696	Advanced Methods in Text Analytics
Form of module	Lecture with exercises
Type of module	Specialization course
Level	Master
ECTS	6
	Hours per semester: 56 h (4 SWS)
Workload	 Self-study: 112 h per semester 84 h: pre and post lecture studying and revision 28 h: examination preparation
Prerequisites	Fundamental notions of linear algebra and probability theory. Suc- cessful completion of "Text Analytics" (IS661), "Machine Learning" (IE675b) or "Deep Learning" (IE678).
Aim of module	This module builds upon the introduction to Natural Language Pro- cessing (NLP) from "Text Analytics" (IS661) and introduces students to cutting-edge problems, techniques and state-of-the-art methods in NLP. The course will focus on neural models of meaning in con- text and present a variety of "Deep Learning" architectures for dif- ferent applications in human language technology (e.g., summari- zation, dialogue systems and machine translation). Moreover, we will cover open research areas, such as the explainability and inter- pretability of NLP models and methods to quantify the degree of bias they exhibit.
Learning outcomes and qualification goals	Expertise: Students will acquire knowledge of state-of-the-art principles and methods of Natural Language Processing, specifically focusing on applying statistical methods to human language technologies. (MK1, MK2, MF3)
	Methodological competence: Successful participants will be able to understand state-of-the-art methods for Natural Language Processing and select, apply and evaluate the most appropriate techniques for various practical and application-oriented scenarios. (MF3)
Media	Lecture and tutorial slides, exercise sheets

Literature	• Dan Jurafsky and James H. Martin, Speech and Language Pro- cessing: An Introduction to Natural Language Processing, Com- putational Linguistics, and Speech Recognition (3rd edition, online available at <u>https://web.stanford.edu/~jurafsky/slp3/</u>).
Methods	Lectures, tutorials
Form of assessment	Written examination
Admission requirements for assessment	-
Duration of assessment	90 minutes
Language	English
Offering	Spring semester
Lecturer	Prof. Dr. Simone Paolo Ponzetto
Person in charge	Prof. Dr. Simone Paolo Ponzetto
Duration of module	1 semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, MSc. Mannheim Master in Data Sci- ence, Lehramt Informatik, MMSDS
Semester	1 st /2 nd /3 rd semester
IE 698	Foundations and Applications of Digital Health Technologies
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Form of module	Lecture with Excercise
Type of module	Specialization Course
Level	Master
ECTS	3
Workload	Hours per semester in presence: 28 h per semester Self-study: 56 h per semester
Prerequisites	Necessary: Basic knowledge about AI systems (knowledge- based systems, machine learning, deep neural networks) Optional: - Participation of Lecture "Responsible AI" Winter Term 2023/24 - Basic knowledge about digital health systems
Aim of module	<u>Conceptual foundations</u> : - Understanding of important concepts in digital health (eHealth, mHealth, telehealth, digital phenotyping, digital twins, and other concepts) <u>Methods</u> : - e.g., interviewing, group discussions, design research methods (prototyping, design thinking, co-design), (digital) ethnography <u>Applications</u> : - Al in digital health apps in medicine and healthcare - Al-based robots - Al-based VR systems
Learning outcomes and quali- fication goals	Knowledge (MK1): Students gain insights and understanding of important concepts in digital health. They learn modes of trans- disciplinary thinking and theorizing on digital health.
	Capabilities (MF1 and MF2): Students learn elements of mixed- methods study design for digital health research and co-design methodology and learn to assess scientific publications in this domain critically.
	Competencies (MKO1): Students learn to critically assess the conceptual, technical, ethical, legal, and social aspects of digital health applications.
Media	Slides and supporting media will be available online.

Literature	 Fagherazzi, G. Deep Digital Phenotyping and Digital Twins for Precision Health: Time to Dig Deeper. Journal of Medical Internet Research 22, e16770 (2020). <u>https://www.imir.org/2020/3/e16770/</u> Hahn, H. & Schreiber, A. E-Health. in Digital Transformation (ed. Neugebauer, R.) 311–334 (Springer Berlin Heidelberg, 2019). <u>https://doi.org/10.1007/978-3-662-58134-6_19</u> Budd, J. et al. Digital technologies in the public-health response to COVID-19. Nat Med 26, 1183–1192 (2020). <u>https://www.na- ture.com/articles/s41591-020-1011-4</u> Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed. 2022. The Cambridge Handbook of Responsible Artificial Intelli- gence: Interdisciplinary Perspectives. Cambridge Law Hand- books. Cambridge: Cambridge University Press. <u>https://doi.org/10.1017/9781009207898</u> (open source)
Methods	Interactive lecture
Form of assessment	Written exam
Admission requirements for assessment	-
Duration of assessment	45 min
Language	English
Offering	Spring semester
Lecturer	JunProf. Dr. Philipp Kellmeyer
Person in charge	Jun.Prof. Dr. Philipp Kellmeyer
Duration of module	1 Semester
Further modules	Lecture on Responsible AI, Fall 2024
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	All semesters possible

IE 699	Co-creating digital health applications with design methodol-
	ogy
Form of module	Excercise
Type of module	Specialization Course
Level	Master
ECTS	6
Workload	Hours per semester in presence: 56 h Self-study: 112 h
Prerequisites	Necessary: Basic knowledge about AI systems (knowledge- based systems, machine learning, deep neural networks) Optional: - Participation of Lecture "Responsible AI" Winter Term 2023/24 - Basic knowledge about digital health systems
Aim of module	<u>Conceptual foundations</u> : Understanding of important concepts in digital health (eHealth, mHealth, telehealth, digital phenotyp- ing, digital twins, and other concepts) <u>Methods</u> : Interviewing, group discussions, design research methods (prototyping, design thinking, co-design), (digital) eth- nography <u>Applications</u> : By-design approaches to developing digital health apps and other solutions.
Learning outcomes and quali- fication goals	Knowledge (MK1): Along with digital health use cases, they learn basic by-design principles for developing digital health applica- tions.
	Capabilities (MF1, MF2, MF3): Students learn elements of mixed-methods study design for digital health research and co- design methodology via design fictions and mockups devel- oped in groups in the exercise
	Competencies (MKO1): Students learn to apply their knowledge and capabilities regarding by-design approaches to solve spe- cific problems in a team context.
Media	Slides and supporting media will be available online.
Literature	- Fagherazzi, G. Deep Digital Phenotyping and Digital Twins for Precision Health: Time to Dig Deeper. Journal of Medical

	Internet Research 22, e16770 (2020).
	https://www.jmir.org/2020/3/e16770/
	- Hahn, H. & Schreiber, A. E-Health. in Digital Transformation
	(ed. Neugebauer, R.) 311–334 (Springer Berlin Heidelberg,
	2019). https://doi.org/10.1007/978-3-662-58134-6 19
	- Budd, J. et al. Digital technologies in the public-health response
	to COVID-19. Nat Med 26, 1183–1192 (2020). <u>https://www.na-</u>
	ture.com/articles/s41591-020-1011-4
	- Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed.
	2022. The Cambridge Handbook of Responsible Artificial Intelli-
	gence: Interdisciplinary Perspectives. Cambridge Law Hand-
	books. Cambridge: Cambridge University Press.
	https://doi.org/10.1017/9781009207898 (open source)
Methods	Excercise
Form of assessment	Presentation in course
Admission requirements for assessment	-
Duration of assessment	20 min (15 min. Presentation, 5 min Q&A)
Language	English
Offering	Spring semester
Lecturer	JunProf. Dr. Philipp Kellmeyer
Person in charge	Jun.Prof. Dr. Philipp Kellmeyer
Duration of module	1 Semester
Further modules	Lecture on Responsible AI, Fall 2024
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik
Semester	All semesters possible

CS 646	Higher Level Computer Vision
Form of module	Lecture with Exercise
Type of module	Specialization Course
Level	Master
ECTS	6
	Hours per semester present: 56 (4SWS)
Workload	Self-study: 98h
	 70h lecture/exercises 28h exam preparation
Prerequisites	Basis skills in linear algebra, basis knowledge in python and pytorch
Aim of module	 Point Features and point matching Object Identification Deep Learning for Computer Vision Object Detection Image Segmentation Optical Flow Video and Motion Segmentation
Learning outcomes and qualification goals	Expertise: The students have a detailed understanding of Com- puter Vision techniques. They can evaluate given Computer Vi- sion algorithms.
	(MK1, MK2, MF1, MF3)
	Methodological competence: Students understand the tech- nical basis of Computer Vision algorithms; they can explain the discussed methods and implement them.
	(MF1, MF2, MF3)
	Personal competence: Understanding complex Computer Vi- sion problems; thorough judgment in the design and use of methods; can work efficiently in a team. (MK01, MK02)
Media	Exercise sheets and lecture slides available online.

Literature	 Goodfellow et al: Deep Learning, MIT Press, 2016. <u>https://www.deeplearningbook.org/</u> R. Szeliski: Computer Vision Algorithms and Applications, Springer, 2010. ISBN: 978-1-84882-934-3. (Online available: <u>http://szeliski.org/Book/</u> D. Forsyth, J. Ponce: Computer Vision: A Modern Approach, Prentice Hall, 2nd edition, 2012. ISBN: 978-0136085928 (Online available: <u>http://cmuems.com/excap/readings/forsyth-ponce- computer-vision-a-modern-approach.pdf</u> R. Hartley, A. Zisserman: Multiple View Geometry in Computer Vision, Cambridge University Press, 2nd edition, 2004.
Methods	Lecture, weekly exercise, book studies, implementation of algo- rithms, visualization of results
Form of assessment	Written or oral examination (TBA)
Admission requirements for assessment	-
Duration of assessment	90 minutes (written) or 20 minutes (oral)
Language	English
Offering	Fall semester
Lecturer	Professor DrIng. Margret Keuper
Person in charge	Professor DrIng. Margret Keuper
Duration of module	1 Semester
Further modules	Image Processing
Range of application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1 st /2 nd /3 rd semester

CS 647	Image Processing
Form of module	Lecture with Exercise (partially online)
Type of module	Specializaton Course
Level	Master
ECTS	6
	Hours per semester present: 56 (4SWS)
Workload	Self-study: 98h
	• 70h lecture/exercises
Droroquisitos	28h exam preparation 28h exam preparation Desis skills in linear algebra basis knowledge in puthen
Prerequisites	Basis skills in linear algebra, basis knowledge in python
Aim of module	 Introduction to Imaging (human visual system, optics, sensors) Noise and basic operations (convolution, correlations, gradients) Energy minimization Variational Methods Feature extraction Classification Segmentation Image Sequences and Motion (Optical Flow) Stereo Vision
	Expertise: The students have a detailed understanding of image and video processing techniques. They can evaluate given image processing algorithms.
	(MK1, MK2, MF1, MF3)
Learning outcomes and qualification goals	Methodological competence: Students understand the technical basis of image processing algorithms; they can explain the discussed methods and implement them.
	(MF1, MF2, MF3)
	Personal competence: Understanding complex Image Processing problems; thorough judgment in the design and use of methods; can work efficiently in a team.
	(МК01, МК02)

Media	Exercise sheets and lecture slides available online.
Literature	 R. Szeliski: Computer Vision Algorithms and Applications, Springer, 2010. ISBN: 978-1-84882-934-3. (Online available: <u>http://szeliski.org/Book/</u>) D. Forsyth, J. Ponce: Computer Vision: A Modern Approach, Prentice Hall, 2nd edition, 2012. ISBN: 978-0136085928 (Online available: Fehler! Linkreferenz ungültig. ponce-computer-vision-a-modern-approach.pdf)
Methods	Lecture, weekly exercise, book studies, implementation of algo- rithms, visualization of results
Form of assessment	Written or oral examination (TBA)
Admission requirements for assessment	-
Duration of assessment	90 minutes (written) or 20 minutes (oral)
Language	English
Offering	Fall Semester/ Spring Semester
Lecturer	Professor DrIng. Margret Keuper
Person in charge	Professor DrIng. Margret Keuper
Duration of module	1 Semester
Further modules	Higher Level Computer Vision
Range of application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1 st /2 nd /3 rd semester

CS 668	Generative Computer Vision Models
Form of module	Lecture with Exercise
Type of module	Specialization Course
Level	Master
ECTS	6
	Hours per semester present: 56 (4SWS)
Workload	Self-study: 98h70h lecture/exercises28h exam preparation
Prerequisites	Basis skills in linear algebra, basis knowledge in python/pytorch
Aim of module	 Introduction to Clustering and Unsupervised Learning Introduction to Generative Models Autoregressive Models for Image Generation (Normalizing) Flow Latent Variable Models Latent Space Visualizations Generative Adversarial Models Diffusion Models Multi-Modal Conditioning
Learning outcomes and qualification goals	Expertise: The students have a detailed understanding of image generation techniques, latent variable models, and their evalua- tions. (MK1, MK2, MF1, MF3) Methodological competence: Students understand the technical basis of generative models; they can explain the discussed meth- ods and implement them. (MF1, MF2, MF3)
	Personal competence: Understanding image generative models, their working principles and training procedures; thorough judg- ment in the design and use of methods; Students can work effi- ciently in a team. (MK01, MK02)
Media	Exercise sheets and lecture slides available online.
Literature	• Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, An MIT press book, 2016.

Methods	Lecture, weekly exercise, book studies, implementation of algorithms, visualization of results
Form of assessment	Written or oral examination (TBA)
Admission requirements for assessment	-
Duration of assessment	90 minutes (written) or 20 minutes (oral)
Language	English
Offering	Spring Semester
Lecturer	Professor DrIng. Margret Keuper
Person in charge	Professor DrIng. Margret Keuper
Duration of module	1 Semester
Further modules	Higher Level Computer Vision
Range of application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, Lehramt Informatik
Semester	1st/2nd/3rd semester

DS 201	Machine Learning and Causal Inference
Form of module	Lecture and Tutorial
Type of module	Data Science Methods: Fundamentals
Level	Master
ECTS	9 (270 hours)
	Hours per semester present: 56 h (2 SWS)
Workload	 Self-study: 214 h per semester 91 h: pre and post lecture studying and revision 42 h: studying for and taking weekly online tests 41 h: preparation and presentation of weekly exercises 40 h: examination preparation
Prerequisites	A sound understanding of basic statistical methods incl. re- gression analysis, estimation methods (OLS, MLE), and statis- tical inference is required. Knowledge in linear algebra and calculus is useful.
Aim of module	The course aims to introduce students to advanced causal in- ference and machine learning methods, discussing models in detail. It first deals with causal inference topics, for instance, synthetic control and its extensions, causal inference in panel and difference-in-difference models. The course also covers estimating mediation effects, controlled direct effects, and gives an introduction to directed acyclic graphs (DAGs). The second part of the course then discusses a theory of causal estimation and the role of machine learning in estimating these effects. Advanced and popular techniques of machine learning are introduced.
Learning outcomes and qualification goals	Expertise: Students are aware of how machine learning can help answer causal questions; they can analyze (large) data sets using popular techniques of machine learning. (MK1)
	Methodological competence: Students are able to translate their research question(s) into a causal framework; they can apply different techniques of machine learning. (MK1, MK3)

	Personal competence:
	The course supports students to develop competences with regard to choosing the appropriate statistical method(s) to answer respective research questions. (MF1, MF2, MF4, MKO1, MKO2)
Media	Lecture slides available online
Literature	 Angrist, Joshua D., and Jörn-Steffen Pischke. 2009. Mostly Harmless Econometrics: An Empiricist's Companion. Princeton: Princeton University Press. Murphy, Kevin P. 2012. Machine Learning: A Probabilistic Perspective. Cambridge: MIT Press. Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. 2008. The Elements of Statistical Learning. 2nd ed. New York: Springer. Imbens, Guido W., and Donald B. Rubin. 2015. Causal In- ference for Statistics, Social, and Biomedical Sciences: An Introduction. Cambridge: Cambridge University Press. Morgan, Stephen L., and Christopher Winship. 2007. Counterfactuals and Causal Inference. Cambridge: Cam- bridge University Press.
Methods	Lecture elements, weekly online tests, literature studies
Form of assessment	Written examination
Admission requirements for assessment	Oral participation, homework, presentations, compulsory at- tendance
Duration of assessment	90 Minutes
Language	English
Offering	Spring semester
Lecturer	Lecturer of the School of Social Sciences, I.e. Chair of Social Data Science
Person in charge	Lecturer of the School of Social Sciences, I.e Chair of Social Data Science
Duration of module	1 semester
Further modules	
Range of application	MMSDS, MMDS

Semester	2 nd semester	
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E. <u>Responsible Data Science</u>

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
CS 652	Data Security and Privacy	FSS**	Е	6	87
	Legal and Ethical Aspects of Privacy	HWS	E	3	89
CS 718	AI and Data Science in Fiction and Society	HWS	E	4	91
AC 654	Additional Course – Responsible Data Science	HWS/FSS	E	Max 18	93
DS 203	Responsible AI: Conceptual Foun- dations, Methods and Applications	HWS	E	6	94

**in FSS24 this course will be offered as hybrid-course.

2. Detailed descriptions

CS 652	Data Security and Privacy
Form of module	Inverted classroom with exercises
Type of module	Specialization course
Level	Master
ECTS	6
Workload	Hours per semester present: 56h (4 SWS)
WOINDau	Self-study: 112h
Prerequisites	There are no formal prerequisites but knowledge in cryptography or IT-security is recommended, e.g., by attending the lectures "Kryptographie I" or "Selected Topics in IT-Security"
Aim of module	Nowadays, users are more and more revealing data to the out- side – either willingly as in the context of data mining or possibly unconsciously as in the case of the Internet of Things. The aim of the module is to raise awareness, in particular with respect to pri- vacy violations. This is done by showing various security threats, e.g., traces left in the Internet such as the use of cookies or browser fingerprinting. In particular, the topic of privacy preser- vation will be covered. This includes discussing different ap- proaches for defining the meaning of privacy but also possible countermeasures such as anonymization of data or the use of dedicated encryption schemes.
	Expertise: Students will acquire the knowledge to identify security and pri- vacy threats and to select and use appropriate countermeasures. (MK2)
Learning outcomes and qualification goals	Methodological competence: Successful participants will be able to understand, to select, apply and evaluate the most appropriate techniques for a variety of dif- ferent privacy-sensitive scenarios. In particular they are able to realize possible risks in new scenarios and to transfer given solu- tions to these. (MK1)

	Personal competence:		
	The analytic, concentrated, and precise thinking of the students is		
	trained. By the independent treatment of applications, e.g. in the		
	course of the exercises, their abstraction capacity is further devel-		
	oped and the transfer of the learned material to related ques-		
	tions is trained.		
	(MF1, MKO3)		
Media	Video recordings, annotated lecture slides		
Literature	Will be announced in the lecture		
	Reworking the lecture and studying the relevant literature in self-		
Mathada	study. During the lecture: discussing questions and ideas and		
Methous	working together on concrete examples. Solving exercises in self-		
	study and in practice in cooperation with fellow students.		
Form of assessment	Written exam		
Admission requirements			
for assessment			
Duration of assessment	90 minutes		
Language	English		
Offering	Spring semester (in FSS24 this course will only be offered as		
	online-course in form of videos)		
Lecturer	Prof. Dr. Frederik Armknecht		
Person in charge	Prof. Dr. Frederik Armknecht		
Duration of module	1 semester		
Further modules	-		
	M.Sc. Mannheim Master in Data Science,		
Range of application	M.Sc. Wirtschaftsinformatik, Lehramt Informatik,		
	M.Sc. Mathematik		
Semester	1 st /2 nd /3 rd semester		

	Legal and Ethical Aspects of Privacy		
Form of module	Lecture		
Type of module	Responsible Data Science		
Level	Master		
ECTS	3		
	Hours per semester present: 28 h (2 SWS)		
Workload	 Self-study per semester: 60 h Pre-and post-lecture studying and preparation (30h) Examination preparation (30h) 		
Prerequisites	None		
Aim of module	In a first section the course will acquaint the students with the origins and basic principles of privacy law mainly in Europe Furthermore, it will contrast the European privacy foundation with the U.S. approach. At the core of this course stands the new European General Data Protection Regulation (GDPR) and its applicability to specific cases and basic principles. Moreo ver, the course will cover current challenges to the existing pri- vacy paradigms by big data and big data analytics. In a second section the course will cover ethical aspects of the use of personal and non-personal data. Data potentially allows to identify and target individuals and offer individualized prod- ucts to them. However, sometimes this kind of individualizat tion might be legal, but the question arises whether it is also desirable from an ethical and societal point of view? The course will use selected examples (e.g., first-degree price dis crimination) in order to illustrate the ambivalence of legality legitimacy, and ethics. In this context, the use of artificial in		
Learning outcomes and qualification goals	 Students will have a basic knowledge on the applicability of the General Data Protection Regulation (GDPR) and its basic principles; be aware of privacy issues and potential legal limitations when processing data; be aware of current challenges to the existing privacy have an understanding why privacy issues are treated differently in Europe and the U.S.; paradigms by big data and big data analytics; be aware of currently discussed new approaches to privacy (e.g., privacy by design); be aware of ethical issues of using personal as well as non-personal data 		

	• be aware of the chances and challenges the use of artificial in- telligence will bring
Media	Video tutorials, lectures, online quizzes
Literature	Students will receive reading assignments for each unit to- gether with the syllabus at the beginning of the semester.
Methods	The class will generally be conducted as a lecture. However, some of the sessions will be conducted on an inverted class- room principle. Students will be able to access the video lec- tures at the beginning of the semester. The content of these videos will be discussed along with additional reading in the individual class sessions.
Form of assessment	written examination
Admission requirements for assessment	Successful participation in 5 out of at least 7 online quizzes
Duration of assessment	90 minutes
Language	English
Offering	HWS
Lecturer	Prof. Dr. Thomas Fetzer
Person in charge	Prof. Dr. Thomas Fetzer
Duration of module	1 semester
Further modules	-
Range of application	MMDS
Semester	1 st /2 nd /3 rd semester

CS 718	AI and Data Science in Fiction and Society
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree
Aim of module	In this seminar, students analyze and discuss fictional works in the area of AI and data science with respect to technologi- cal and societal aspects. The present the results orally and in a written report.
Learning Outcomes and Qualification Goals	Expertise: Students will learn about societal effects of AI and data sci- ence and become aware of potential threats and dangers, but also of chances of those new technologies. (MK1)
	Methodological competence: Students will develop methods and skills to find relevant lit- erature for his/her topic, and to write a well-structured scien- tific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF1, MF2, MF3)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, discuss a fictional work using secondary literature as background material, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's The- sis.
Media	Fictional and non-fictional texts
Literature	A detailed literature list is compiled for each offering.
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member

	Seminar paper (length: 15-20 pages depending on the topic),		
Form of Assessment	Peer Review (up to 10 pages), Presentation (20-30) minutes		
	depending on the topic)		
Admission requirements			
for assessment			
Duration of Assessment	6-8 weeks (writing of the essay), 20-30 minutes (presenta-		
Duration of Assessment	tion).		
Language	English		
Offering	Fall semester		
Lecturers	Prof. Dr. Heiko Paulheim and research staff members		
Person in charge	Prof. Dr. Heiko Paulheim		
Duration of module	1 semester		
Further modules	-		
Range of Application	MMDS, M. Sc. Wirtschaftsinformatik, Lehramt für Gymnasien		
Semester	3. Semester		

AC 654	Additional Course – Responsible Data Science
Form of module	Depends on course
Level	Master
ECTS	Max. 18
Workload	Depends on course
Prerequisites	Depends on course
Aim of module	The course falls into the responsible data science area of the MMDS and covers topics related to responsible data science but is not directly equivalent to any course in the MMDS module catalogue. The course level equals a regular course in MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Meth- ods / Form and duration of assessment	Depends on course
Language	English preferred, but any other language possible if Mann- heim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	2 nd /3 rd /4 th semester

DS 203	Responsible AI: Conceptual Foundations, Methods and Ap-		
	plications		
Form of module	Lecture with Essay		
Type of module	Specialization Course		
Level	Master		
ECTS	6		
Workload	Hours per semester in presence: 28 (2 SWS) Self-study: 56 h lectures; 20 h essay / preparation oral exam		
Prerequisites	Basic knowledge about AI systems (knowledge-based systems, machine learning, deep neural networks)		
Aim of module	<u>Conceptual foundations</u> : - understanding of important concepts in human-AI interaction and AI ethics (such as trust, autonomy, responsibility) <u>Methods</u> : - e.g., narrative interviews, group discussions, design research methods (prototyping, design thinking, techno-mimesis), (digital) ethnography, participatory action research <u>Applications</u> : - AI in medicine and healthcare - Social robotics - Generative AI - other use cases / real-world AI applications		
Learning outcomes and qualification goals	Expertise: Students gain insights and understanding of important concepts in human-AI interaction and AI ethics. They learn modes of transdisciplinary thinking and theorizing. Along sector-specific use cases they learn about ethical, legal and social aspects and challenges of real-world AI application, e.g. for healthcare. Methodological competence: Students learn elements of mixed- methods study design for human-AI interaction research Personal competence: Students learn to critically assess concep-		
	tual, ethical, legal and social aspects of human-AI interaction. They gain skills in transdisciplinary research and theory-building and learn to transfer these insights to real-world human-AI inter- action scenarios.		
Media	Slides are available online		
Literature	- Voeneky, S., P. Kellmeyer, O. Mueller, and W. Burgard, ed. 2022. The Cambridge Handbook of Responsible Artificial Intelligence:		

	Interdisciplinary Perspectives. Cambridge Law Handbooks. Cam-					
	bridge: Cambridge University Press.					
	https://doi.org/10.1017/9781009207898 (open source)					
	- Coeckelbergh, Mark. AI ethics. (2020). The MIT Press.					
	https://www.gbv.de/dms/bowker/toc/9780262538190.pdf					
	- Heilinger, JC. (2022). The Ethics of AI Ethics. A Constructive Cri-					
	tique. Philosophy & Technology, 35(3), 61.					
	https://doi.org/10.1007/s13347-022-00557-9					
	- McLennan, S., Fiske, A., Tigard, D., Müller, R., Haddadin, S., &					
	Buyx, A. (2022). Embedded ethics: A proposal for integrating eth-					
	ics into the development of medical AI. BMC Medical Ethics, 23(1),					
	6. https://doi.org/10.1186/s12910-022-00746-3					
	- Schmitt, L. (2021). Mapping global AI governance: A nascent re-					
	gime in a fragmented landscape. Al and Ethics.					
	https://doi.org/10.1007/s43681-021-00083-y					
Methods	Interactive lecture					
Form of assessment	Essay					
Admission requirements						
for assessment						
Duration of assessment	Essays need to be handed in by December 8th					
Language	English					
Offering						
	Fall comestor					
Lecturer	JProf. Dr. Philipp Kellmeyer					
Person in charge	JProf. Dr. Philipp Kellmeyer					
Duration of module	1 Semester					
Further modules	Follow-up (block) seminar planned for summer semester 2024					
Range of application	Msc Business Informatics, Msc Data Science, Lehramt Informatik					
Semester	All semesters possible					

F. Projects and Seminars

1. Overview

Module no.	Name of Module	Offered	Language	ECTS	Page
AC 653	Additional Course – Projects and Seminars	HWS/FSS	E	Max. 18	97
TP 500	Team Project	HWS/FSS	G/E	12	98
IP 500	Individual Project	HWS/FSS	G/E	8	101
SQ 500	Scientific Research	Irregular	E	2	103
CS 701	Seminar Selected Topics in Algo- rithmics and Cryptography	Irregular	E	4	105
CS 704	Master Seminar Artificial Intelli- gence	Irregular	E	4	107
CS 707	Hot Topics in Machine Learning Seminar	Irregular	E	4	109
CS 708	Seminar Software Engineering	Irregular	E	4	111
CS 709	Seminar Text Analytics	Irregular	G/E	4	113
CS 710	Seminar Prof. Paulheim	Irregular	G/E	4	115
CS 715	Seminar Large Scale Data Integra- tion	Irregular	E	4	117
CS 716	Seminar Prof. Armknecht	Irregular	E	4	119
CS 717	Master Seminar on Computer	HWS/FSS	E	4	121
CS 720	Uncertainty Estimation	Irregular	E	4	123
CS 721	Seminar Data-Science I	Irregular	E	4	125
CS 722	Seminar Ethical Aspects of Al	Irregular	E	4	127
IE 704	Seminar AI Systems Engineering	Irregular	E	4	129
IS 752	Seminar on Process and Manage- ment Analytics	FSS	E	4	MMM*

* For a detailed description, please see the module catalogues of the respective following degree programs:

MMM: Mannheim Master in Management
 <u>https://www.bwl.uni-mannheim.de/studium/master/mmm/#c176637</u>

2. Detailed descriptions

AC 653	Additional Course – Projects and Seminars
Form of module	Depends
Level	Master
ECTS	Max. 18
Workload	Depends
Prerequisites	Depends
Aim of module	The course equals a seminar in the MMDS study program. The module can be taken either at the University of Mannheim or at any other university in Germany or abroad.
Learning outcomes and qualification goals	Depends on course
Media / Literature / Meth- ods / Form and duration of assessment	Depends
Language	English preferred, but any other language possible if Mann- heim faculty member is able to identify content and level
Offering	Spring semester / Fall semester
Lecturer	Lecturer at the host university
Person in charge	Lecturer at the host university
Duration of module	1 Semester
Further modules	-
Range of application	MMDS
Semester	2 nd /3 rd /4 th semester

TP 500	Team Project
Form of module	Project
Type of module	Team Project
Level	Master
ECTS	12 in two consecutive semesters or 12 in one semester
Workload	Hours per semester: 12 month-project: 28 h (2 SWS) 6 month-project: 56 h (4 SWS)
	 Self-study: 140 h per semester (12 month project); 112 h: pre and post lecture studying, revision and free self-study 28 h: preparation of examination/presentation Self-study: 280 h per semester (6 month project) 224 h: pre and post lecture studying, revision and free self-study 56 h: preparation of examination/presentation
Prerequisites	Depends on topic
Aim of module	The students solve a practical problem as a team. The participants have to analyze and refine the problem and come up with a project plan for developing a concrete solution that will be carried out by the team over the duration of a whole year. Concrete topics for projects are defined by the supervisors and offered to the students who can apply for different topics. Problem area and techniques involved depend on the expertise of the offering chair.
Learning outcomes and qualification goals	 Depending on the actual topic of the project, participants will acquire in depths knowledge in a certain application of business informatics and data science knowledge about methods and technologies typically applied in the application area knowledge about practical problems and challenges when applying a certain technique in a given application area (MK1, MK2, MK3)

	Participants will learn to
	 refine a given problem statement by analyzing requirements and the state of the art using techniques like literature research and expert interviews.
	 Define a workplan including tasks, milestones, deliverables and
	resources and continually assess and modify the plan according
	to the actual progress of the work.
	(MF1, MF2, MF3, MF4)
	Being a team effort, the project explicitly targets personal compe- tence in terms of
	 working in and managing a team of experts possibly from dif-
	ferent academic and cultural backgrounds
	 taking part in discussions and learning to contribute the own opinion without overruling other opinions
	 self-management and responsibility within the requirements of
	collaborative work
	(MKO1, MKO2, MKO3)
Media	Depends on project
Literature	Depends on topic
Mathada	Team-discussions, Presentations, Teamwork, Individual prepara-
Methods	tion of empirical contributions; self-study
Form of assessment	One or more reports totaling 50 - 120 pages (depending on the topic) and presentation (10-90 minutes).
Admission requirements for assessment	12-month project: withdrawal within the first 6 weeks possible without failing
	6-month project: withdrawal within the first 3 weeks possible with- out failing
	Final report (length: one of more reports totalling 50-120 pages de-
Duration of assessment	pending on the topic), presentation (10-90 minutes depending on
	the topic).
Language	English
Offering	Spring semester/Fall semester
Locturor	Professors of the Institute of Computer Science and Business Infor-
	matics or of the Area Information Systems of the Business School
Person in charge	Professors of the Institute of Computer Science and Business Infor- matics or of the Area Information Systems of the Business School

Duration of module	1 semester or 2 semesters
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence
Semester	1 st /2 nd /3 rd semester

IP 500	Individual Project
Form of module	Project
Type of module	Individual Project
Level	Master
ECTS	8
Workload	Self study: 240 h per semester
Prerequisites	Depends on topic
Aim of Modules	The student solves a practical problem individually. The stu- dent has to analyse and refine the problem and come up with a project plan for developing a concrete solution. Concrete topics for projects are defined by the supervisors and offered to the students who can apply for different topics. Problem area and techniques involved depend on the expertise of the offering chair.
Learning outcomes and qualifications goals	 Depending on the actual topic of the project, participants will acquire in-depth knowledge in a certain application of data science knowledge about methods and technologies typically applied in the application area knowledge about practical problems and challenges when applying a certain technique in a given application area (MK1, MK2, MK3)
	 Participants will learn to refine a given problem statement by analysing requirements and the state of the art using techniques like literature research and expert interviews. define a workplan including tasks, milestones, deliverables and resources and continually assess and modify the plan according to the actual progress of the work. (MF1, MF2, MF3, MF4, MKO3)
Media	Depends on project
Literature	Depends on topic
Methods	Self-study, presentations
Form of Assessment	Final report (length: 10-50 pages depending on the topic), presentation (15-30 minutes depending on the topic).

Admission requirements for assessment	-
Duration of Assessment	6 months (execution of the project and writing of the report), 15-30 minutes (presentation).
Language	English/German
Offering	Irregular
Lecturer	Professors of the Institute of School of Business Informatics and Mathematics or of the School of Social Sciences
Person in Charge	Professors of the Institute of School of Business Informatics and Mathematics of the School of Social Sciences
Duration of module	1 semester
Further modules	-
Range of Applications	MMDS
Semester	1 st /2 nd /3 rd semester

SQ 500	Scientific Research
Form of module	Seminar
Type of module	Key Qualification
Level	Master
ECTS	2
Workload	80% (48 hours) self-study and 20% (12 hours) coursework
Prerequisites	None
Aim of module	This course focuses on the basic key competences that are needed to successfully write a scientific paper or a thesis. It is recom- mended that you take this module before you participate in a sem- inar.
	 Topics include: Scientific process and scientific writing Bibliographic research methodology Search strategies in bibliographic databases Finding data for your research How to read, understand and cite scientific literature Reference management systems and LaTeX
Learning outcomes and qualification goals	Expertise: The students understand how to work scientifically and how to write a thesis.
	Methodological competence: The students can find relevant publications for a research question.
	 Personal competence: Everybody wrote a short overview of his/her research question. Everybody installed and used exemplary tools to support the work process
Literature	 The craft of research / Wayne C. Booth; Gregory G. Colomb; Joseph M. Williams (Chicago guides to writing, editing, and publishing); 3. ed.; Chicago, Ill.; [u.a.] : University of Chicago Press, 2008; XVII, 317 S. : graph. Darst.; 22cm. LaTeX (Wikibook): http://en.wikibooks.org/wiki/LaTeX
Methods	Seminar

Form of assessment	Online
Admission requirements for assessment	-
Duration of assessment	150 minutes
Language	English
Offering	Spring semester/Fall semester
Lecturer	Lecturer from the University Library (UB)
Person in charge	Lecturer from the University Library (UB)
Duration of module	3 weeks
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, MMDS
Semester	1 st /2 nd /3 rd semester

CS 701	Selected Topics in Algorithmics and Cryptography
Form of module	Seminar
Type of module	Seminar
Level	Master
ECTS	4
Workload	120 h per Semester
Prerequisites	Algorithmics (CS 550) or Cryptography II (CS 651) or Courses in Al- gorithms or Cryptography or Theoretical Computer Science or Complexity Security at B.Sc. or M.Sc. Level, key qualification scien- tific research.
Aim of module	The students prepare a scientific report on a current research topic on the basis of published papers under guidance of a scientific staff member and gives a presentation. The topic will be proposed by the professor, but the students may also propose topics. Active participation in the seminar presentations of fellow students will be expected.
Learning outcomes and qualification goals	Expertise: The students gain a deep understanding of the research topic, are able to explain the topic in detail in a clean and transparent ways and are able to classify the significance of the topic and the results in relation to the current state of research in the corresponding re- search area. (MK1, MK2, MK3)
	Methodological competence: The students are able to read, to understand and to explore scien- tific literature relevant to the topic. They are aware of the need to avoid plagiarism. (MF2)
	Personal competence: The student has learned how to find relevant literature for a re- search topic, write a well structured and clear report about it and give a presentation. The seminar serves also as preparation for writing and presenting the master thesis. (MF2)
Media	Scientific papers and books. Presentation systems like PowerPoint or beamer Latex.

Literature	Depends on the topic.
Methods	Do scientific work independently under the guidance of a research staff member and manage an active discussion on the topic in a groups of peers.
Form of assessment	Presentation and discussion (15-60 minutes), Written essay/report (5-25 pages), Participation.
Admission requirements for assessment	Timely hand-in of seminar papers and presentation materials
Duration of assessment	60 minutes presentation with 15-30 minutes discussion; written report (length: 5-25 pages).
Language	English
Offering	Irregular
Lecturer	Matthias Krause, Alexander Moch, Matthias Hamann
Person in charge	Prof. Dr. Matthias Krause
Duration of module	1 Semester
Further modules	-
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence, M.Sc. Wirtschaftsmathematik
Semester	3 rd semester

CS 704	Master Seminar Artificial Intelligence
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Decision Support or Data Mining or Knowledge Management
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State-of-the- art topics are proposed by the professors. The paper and the presentation are prepared under the guidance of a professor or a research staff member. Active participation in the seminar discus- sions is expected.
Learning Outcomes and Qualification Goals	Expertise: The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribu- tion of the research papers. (MK1, MK2, MK3) Methodological competence: The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2) Personal qualification:
	Personal qualification: The student has learned how to write a well-structured, concise pa- per and give a presentation. This is part of the preparation to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; final presentation with latex slides
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific reading independently under the guidance of a profes- sor or a research staff member. Active discussions in a group of peers.

Form of Assessment	Presentation (15 – 60 minutes) and Seminar Report (5-25 pages depending on topic), individual or as a group (depending on topic)
Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the report), 15-60 minutes (presentation).
Language	English
Offering	Irregular
Lecturers	Prof. Dr. Heiner Stuckenschmidt
Person in charge	Prof. Dr. Heiner Stuckenschmidt
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence
Semester	3 rd semester
CS 707	"Hot Topics in Machine Learning" Seminar
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Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	The student prepares a scientific report and gives at least one presenta- tion on a current research topic based on published research papers. The topics lie in the area of Data and Web Science and are proposed by the professor or the student. Report and presentations are prepared under the guidance of a professor or a research staff member. The student may also moderate a discussion of a presentation of a fellow student, act as a peer reviewer for the presentations or reports of other students, or ex- periment with a data analysis system. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	Expertise: The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contributions of the research papers.
	Methodological competence: The student is able to read, understand, and explore scientific literature relevant to his/her topic. He/she is also aware of the need to avoid pla- giarism. The key qualification Scientific Research is recommended as a prerequisite for this seminar.
	Personal qualification: The student has learned how to find relevant literature for a research topic, write a well-structured, concise report about it and give presenta- tions. He/she will be well prepared to write and present a Bache- lor's/Master's Thesis.
Media	Scientific papers and books; software and datasets; final presentation with PowerPoint or similar software
Literature	Depends on the topic of the seminar
Teaching and Learning Meth- ods	Do scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Individual grading of the seminar paper, the oral presentations, the peer reviews (if applicable), the created source code (if applicable), the active participation in the seminar, and the timeliness of hand-ins.
Admission requirements for assessment	-
Duration of Assessment	N/A

Language	English
Offering	HWS, sometimes also FSS
Lecturers	Prof. Dr. Rainer Gemulla or research staff member
Person in charge	Prof. Dr. Rainer Gemulla or research staff member
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, MSc. Mannheim Master in Data Science, Lehramt für Gymnasien
Semester	3 rd semester

CS 708	Seminar Software Engineering
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	Students prepares a scientific paper and gives a presentation on a current software engineering research topic based on published research papers. State-of-the-art topics are proposed by the software engineering group. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	Expertise: The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribu- tion of the research papers. (MK1, MK2, MK3)
	Methodological competence: The student is able to find the relevant literature for his/her topic, to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar.
	(MF2)
	The student has learned how to find relevant literature for a re- search topic, write a well-structured, concise paper about it and give a presentation. (MF2)
Media	Scientific papers and books, final presentation
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Scientific work performed independently under the guidance of a member of the software engineering group. Active discussions in a group of peers.

Form of Assessment	Quality of the seminar paper (5- 25 pages) and the oral presenta-
	tion (15-60 minutes). (Notification will be given at the start of the
	lecture period for this module)
Duration of Assessment	6-8 weeks (writing of the report 5-25 pages), 15-60 minutes (presentation).
Language	English
Offering	Irregular
Lecturer	Member of the software engineering group
Duration	1 semester
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci-
	ence,
Semester	1./ 2. /3. Semester

CS 709	Seminar Text Analytics
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	IS 661 "Text Analytics" or IE 663 "Web Search and Information Re- trieval". Fundamental notions of linear algebra and probability the- ory.
Aim of module	In this seminar, students write a survey/scientific paper and pro- vide an overview presentation of state-of-the-art research, as found within the existing literature (i.e., published research pa- pers). Topics of interest focus around a variety of problems and tasks from the fields of Natural Language Processing and Infor- mation Retrieval. The paper and the presentation are prepared un- der the guidance of a professor or a research staff member.
Learning Outcomes and Qualification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	Methodological competence: Students will develop methods and skills to find relevant literature for his/her topic, to write a well-structured survey/scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, write a well-structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; presentation with PowerPoint or La- TeX.

Literature	Depends on the topic of the seminar
Teaching and Learning	Do scientific work independently under the guidance of a professor
Methods	or a research staff member. Active discussions in a group of peers.
Form of Assessment	Seminar report (length: 5-25 pages); oral presentation (15-60 minutes)
Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the report 5-25 pages), 15-60 minutes (presentation).
Language	English or German
Offering	Irregular
Lecturers	Prof. Dr. Simone Paolo Ponzetto
Person in charge	Prof. Dr. Simone Paolo Ponzetto
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3 rd semester

CS 710	Selected Topics in Data Science
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data Mining, Web Mining, or the Semantic Web.
Learning Outcomes and Qualification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific ex- periments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-struc- tured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member

	Seminar paper (length: 5-25 pages depending on the topic), Peer
Form of Assessment	Review (1-10 pages depending on the topic), Presentation (15-60
	minutes depending on the topic).
Admission requirements for	
assessment	
Duration of Assessment	6-8 weeks (writing of the essay), 15-60 minutes (presentation).
Language	English or German
Offering	Irregular
Lecturers	Prof. Dr. Heiko Paulheim and research staff members
Person in charge	Prof. Dr. Heiko Paulheim
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci-
	ence, Lehramt für Gymnasien
Semester	3 rd semester

CS 715	Large-Scale Data Integration Seminar
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Information Extraction, Schema Matching, Iden- tity Resolution, Data Fusion, Data Mining, Web Mining.
Learning Outcomes and Qualification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3) Methodological competence:
	for his/her topic, to prepare methodologically sound scientific ex- periments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-struc- tured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books
Literature	Depends on the topic of the seminar

Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member
Form of Assessment	Seminar paper (length: 5-25 pages depending on the topic).
Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the seminar paper)
Language	English
Offering	Irregular
Lecturers	Prof. Dr. Christian Bizer and research staff members
Person in charge	Prof. Dr. Christian Bizer
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci- ence, Lehramt für Gymnasien
Semester	3 rd semester

CS 716	IT-Security
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	The student gives a presentation on a current research topic based on published research papers. The topics are proposed by the professor (but the student may also propose topics). The presentation is prepared under the guidance of a professor or a research staff member. The student may also moderate a discus- sion of a presentation of a fellow student or act as a peer re- viewer for the presentations or reports of other students. Active participation in the seminar discussions is expected.
Learning Outcomes and Qualification Goals	Expertise: The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribu- tions of the research papers. (MK1, MK2, MK3) Methodological competence: The student is able to read, understand, and explore scientific lit- erature relevant to his/her topic. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is recommended as a prerequisite for this seminar. (MF2)
	Personal qualification: The student has learned how to find relevant literature for a re- search topic, write a well-structured, concise report about it and give a presentation. He/she will be well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; final presentation with PowerPoint or similar software
Literature	Depends on the topic of the seminar

Teaching and Learning Methods	Do scientific work independently under the guidance of a profes- sor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Grading of the oral presentation and the seminar paper.
Admission requirements for assessment	Timely hand-in of seminar paper and presentation
Duration of Assessment	60 minutes talk, 30 minutes discussion
Language	English
Offering	Irregular
Lecturers	Prof. Dr. Armknecht
Person in charge	Prof. Dr. Armknecht
Duration of module	1 semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, Lehramt für Gymnasien, M.Sc. Wirt- schaftsmathematik
Semester	3rd Semester

CS 717	Master Seminar on Computer Vision
Form of module	Seminar
Type of module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Higher Level Computer Vision or Image Processing
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State-of-the-art topics are proposed by the professors. The paper and the presentation are prepared under the guidance of a professor or a research staff member. Active participation in the seminar discussions is expected.
Learning outcomes and qualification goals	Expertise: The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribution of the research papers.
	Methodological competence: The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid pla- giarism. The key qualification Scientific Research is highly recom- mended as a prerequisite for the seminar.
	Personal qualification: The student has learned how to write a well- structured, concise paper and give a presentation. This is part of the preparation to write and present a Master's Thesis.
Media	Scientific papers and books
Literature	Depending on the topic of the seminar

Methods	Do scientific reading independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of assessment	30% Presentation (takes place after one month) 70% Seminar Report (has to be submitted after three month)
Admission requirements for assessment	
Duration of assessment	N/A
Language	English
Offering	HWS/FSS
Lecturer	Margret Keuper
Person in charge	Margret Keuper
Duration of module	1 Semester
Further modules	
Range of application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science
Semester	3 rd Semester

CS 720	Uncertainty Estimation
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	Bachelor degree, the fundamentals
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data Mining, Web Mining, or the Semantic Web.
Learning Outcomes and Qualification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3) Methodological competence: Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific ex- periments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2) Personal qualification:
	Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-struc- tured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books
Literature	Depends on the topic of the seminar
Teaching and Learning Methods	Do scientific work independently under the guidance of a professor or a research staff member

	Seminar paper (length: 5-25 pages depending on the topic), Peer
Form of Assessment	Review (1-10 pages depending on the topic), Presentation (15-60
	minutes depending on the topic).
Admission requirements	-
for assessment	
Duration of Assessment	6-8 weeks (writing of the report), 15-60 minutes (presentation).
Language	English or German
Offering	Irregular
Lecturers	Tobias Weller
Person in charge	Prof. Dr. Heiko Paulheim
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci-
	ence, Lehramt für Gymnasien
Semester	3 rd semester

CS 721	Seminar Data-Science I
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	There are no formal requirements. However, previous participation in the courses "Network Science" and "Text Analytics" are recom- mended.
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experiment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data-Science, Network Science and Text Mining.
Learning Outcomes and Qualification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	Methodological competence: Students will develop methods and skills to find relevant literature for his/her topic, to prepare methodologically sound scientific ex- periments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well-struc- tured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Master's Thesis. (MF2)
Media	slides, scientific papers, blackboard (electronic)
Literature	Depends on the topic.

Teaching and Learning	Self-study of assigned material, presentation of scientific articles,
Methods	joint discussion of work, collaboration with peers
Form of Assessment	Written report (length: 5-25 pages depending on the topic) with
	oral presentation (15-60 minutes depending on the topic).
Admission requirements	-
for assessment	
Duration of Assessment	6-8 weeks (writing of the essay), 15-60 minutes (presentation).
Language	English
Offering	Irregular
Lecturers	Markus Strohmaier, Marlene Lutz
Person in charge	Markus Strohmaier, Marlene Lutz
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Sci-
	ence, M. Sc. Mannheim Master Management
Semester	3 rd semester

CS 722	Seminar Ethical Aspects of Al
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	IS 661 "Text Analytics" or IE 675b "Machine Learning" or IE 678 "Deep Learning" or IE 560 "Decision Support"
Aim of module	In this seminar, students perform scientific research, either in the form of a literature review or by conducting a small experi- ment, or a mixture of both, and prepare a written report about the results. Topics of interest focus around a variety of problems and tasks from the fields of Data-Science, Network Science and Text Mining.
Learning Outcomes and Qual- ification Goals	Expertise: Students will acquire a deep understanding of the research topic. He/she is expected to describe in-depth and summarize the topic in detail in his/her own words, as well as to judge the contribution of the research papers to ongoing research. (MK1, MK2, MK3)
	Methodological competence: Students will develop methods and skills to find relevant litera- ture for his/her topic, to prepare methodologically sound scien- tific experiments, and to write a well-structured scientific paper and to present his/her results. He/she will be also aware of the need to avoid plagiarism. The key qualification Scientific Re- search is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification: Students will acquire skills on how to find relevant literature for a research topic, organize a small research task, write a well- structured, concise paper about it and present the results of their work. He/she is well prepared to write and present a Mas- ter's Thesis.
Media	Scientific papers and books; presentation with PowerPoint or LaTeX.

Literature	Up-to-date literature will be assigned during the seminar.
Teaching and Learning Meth- ods	Review scientific work independently under the guidance of a professor or a research staff member. Active discussions in a group of peers.
Form of Assessment	Written report (length: 5-25 pages depending on the topic) with oral presentation (15-60 minutes depending on the topic).
Admission requirements for assessment	-
Duration of Assessment	6-8 weeks (writing of the essay), 15-60 minutes (presentation).
Language	English
Offering	Irregular
Lecturers	Markus Strohmaier, Simone Ponzetto
Person in charge	Markus Strohmaier, Simone Ponzetto
Duration of module	1 semester
Further modules	-
Range of Application	M. Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data Science, M. Sc. Mannheim Master Management
Semester	3 rd semester

IE 704	Seminar AI Systems Engineering
Form of Module	Seminar
Type of Module	Seminar
Level	Master
ECTS	4
Workload	120 h per semester
Prerequisites	None
Aim of module	The student prepares a scientific paper and gives a presentation on a current research topic based on published research. State- of-the-art topics are proposed by the supervisors. The paper and the presentation are prepared under the guidance of a re- search staff member. Active participation in the seminar discus- sions is expected.
Learning Outcomes and Qual- ification Goals	Expertise The student gains a deep understanding of the research topic. He/she is able to describe/summarize the topic in detail in his/her own words. He/she reflects on the topic and judges the contribution of the research papers. (MK1, MK2, MK3)
	<u>Methodological competence</u> The student is able to write a well-structured scientific paper and to present his/her results. He/she is also aware of the need to avoid plagiarism. The key qualification Scientific Research is highly recommended as a prerequisite for the seminar. (MF2)
	Personal qualification The student has learned how to write a well-structured, concise paper and give a presentation. This is part of the preparation to write and present a Master's Thesis. (MF2)
Media	Scientific papers and books; final presentation with PowerPoint
Literature	Depends on the topic of the seminar.
Teaching and Learning Meth- ods	Do scientific work independently under the guidance of a pro- fessor or a research staff member. Active discussions in a group of peers.
Form of Assessment	25% Reviews and Discussion (Review: 1-3 pages)

	25% Presentation (15 minutes presentation and 10 minutes dis-
	cussion)
	25% Seminar paper submitted for review (max 20 pages in
	springer proceedings format)
	25% "Camera-ready" seminar paper (max 20 pages in springer
	proceedings format)
Admission requirements for	-
assessment	
Duration of Assessment	writing time for papers and reviews 4 to 8 weeks
Language	English
Offering	Irregular
Lecturers	Dr. Christian Bartelt
Person in charge	Dr. Christian Bartelt
Duration of module	1 Semester
Further modules	-
Range of Application	M.Sc. Wirtschaftsinformatik, M.Sc. Mannheim Master in Data
	Science
Semester	3. Semester

G. Master Thesis

	Master Thesis
Form of module	Master Thesis
Type of module	Thesis
Level	Master
ECTS	30
Workload	Self study: 840 h per semester
Prerequisites	-
Aim of Modules	Develop a deep understanding of an advanced topic of data science
Learning outcomes and qualifications goals	Expertise: The student has a deep understanding of an advanced topic. (MK1)
	Methodological competence: The student is familiar with methods for analysing and inde- pendently solving advanced, complex problems. (MK1, MK2, MK3)
	Personal competence: The student has the capability to understand, analyse and in- dependently find solutions to advanced, complex problems. The student has the capability to assess and understand the state-of-the-art in business informatics and adapt the latest technologies and methods to solve real world problems. The student is able to present a complex topic in written and oral form in a clear and understandable way. (MF1, MF2, MF3, MF4, MKO2, MKO3)
Media	Various
Literature	Topic dependent
Methods	Independent research work
Form of Assessment	Written thesis
Admission requirements for assessment	To be permitted to write the master thesis, the student is to obtain at least 60 ECTS
Duration of Assessment	-

Languages	English only
Offering	Every semester
Person in Charge	Examiners: University teachers, auxiliary professors, honorary professors and senior academic staff members of the School of Business informatics and mathematics or of the School of Social Sciences. Supervisors of other faculties are possible upon application to the examination board and after examina- tion of the content.
Duration of module	1 semester
Further modules	-
Range of Applications	MMDS
Semester	4 th semester

Abbreviations

Explanation of abbreviations

Knowledge

This degree program provides students with a solid theoretical foundation as well as practical skills for data management, data analytics methods and responsible data science. The courses are divided into two groups – fundamental courses and advanced courses. After studying optional fundamental courses in computer science and empirical social sciences, in their advanced courses students can focus on the concepts and methods of computers science and advanced empirical methods and the application of these methods. In addition to the regular lecture courses, students participate in a one or two semester team project or individual project.

During their studies -

- (MK1) all students develop a deep understanding of the relevant concepts, methods and problem-solving strategies used in different application domains.
- (MK2) technology-oriented students learn the concepts, algorithms and strategies used to solve concrete, practical application-oriented problems in informatics.
- (MK3) social sciences-oriented students develop a deep understanding of how to set up, analyse and interpret advanced empirical research questions.

As part of this education, students become familiar with a wide range of models, modelling languages, methods, and tools. Regardless of their specialization, students also learn how to collect, structure, manipulate, prepare, interpret, communicate, and use data, information, and knowledge.

Capabilities

After completing their studies, students have the ability to -

- (MF1) apply a wide range of abstraction and analysis techniques.
- (MF2) understand, interpret, describe, and present relevant scientific publications.

(MF3) exploit the latest scientific results.

- (MF4) independently tackle problems in data management and analytics and describe their results in a structured, written form.
- (MF5) continue their studies at the PhD level, if their results are of sufficient quality.

Competencies

After completing their studies, students have the competences needed to -

- (MKO1) apply their knowledge and capabilities to solve specific problems in a team context.
- (MKO2) use their interdisciplinary education to mediate between technical and nontechnical individuals.
- (MKO3) evaluate the latest changes in programming languages, systems, models and, wherever possible, exploit them to develop better solutions to data-science related problems.