Module manual for
Media Informatics
MSMI

SPO Version 2019
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Module manual for Media Informatics (Master (1-Subject))

Module manual for
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MSMI

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Examination Regulation Title & Version:
Media Informatics (SPO Version / 2019)

Title	Media Informatics
Short title	MSMI
Version	2019
Description	
Qualification Profile	
Additionnal information	

RWTH AACHEN UNIVERSITY

– Computer Graphics
+ Computer Graphics (1212310)

Module titel	Computer Graphics (Compulsory elective subject)
Identifier	1212310
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2007
Valid until	-
Module level	Bachelor/Master
Content	Foundations of geometry representations (polygonal meshes, volumetric representations, freeform curves and surfaces), local illumination (3D transformations, clipping, rasterization, lighting, shading), global illumination (visibility, shadow computation, ray tracing, radiosity), foundations of image processing (transformations, color coding, image compression), volume rendering.
Learning objective	Knowledge of the most important data structures for the representation of three-dimensional objects and scene descriptions. Skills: Learning the elementary operations and methods for transforming a 3D model into a realistic two-dimensional image (rendering pipeline). Competences: Overview of the central problems and their efficient solutions in the field of computer graphics.
Requirements	None.
(recommended) Requirements	Knowledge about Algorithms and Data Structures and Linear Algebra.
References	Tomas Akenine-Möller et al.: Real-Time Rendering (3rd Edition). Taylor & Francis, 2008 | Alan Watt: 3D Computer Graphics (3rd Edition). Addison-Wesley, 1993
Language	German/English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Leif Kobbelt
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Introduction to Computer Graphics (121231002)	5th semester	no semester recommended	0	3
Exam Introduction to Computer Graphics (121231001)	5th semester	no semester recommended	6	5

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Introduction to Computer Graphics	5th semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

– Computer Graphics
+ Introduction to Computer Graphics (KP20925)

Module titel	Introduction to Computer Graphics (Compulsory elective subject)
Identifier	KP20925
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Foundations of geometry representations (polygonal meshes, volumetric representations, freeform curves and surfaces) Local illumination (3D transformations, clipping, rasterization, lighting, shading) Global illumination (visibility problem, shadow computation, ray tracing), radiosity Foundations of image processing (transformations, color coding, image compression) Volume rendering
Learning objective	Knowledge of the most important data structures for the representation of 3-dimensional objects and scenes. | Skills: Basic operations and methods for the transformation of a 3D model into a realistic 2-dimensional images (rendering pipeline). | Competences: Overview of the central problems and their efficient solutions in the whole area of Computer Graphics.
Requirements	None.
(recommended) Requirements	Knowledge of Algorithms, Data Structures and Linear Algebra.
References	Marschner, S. and Shirley, P., 2015. Fundamentals of computer graphics. CRC Press; Ganovelli, F., Corsini, M., Pattanaik, S. and Di Benedetto, M., 2015. Introduction to computer graphics: a practical learning approach. CRC Press; Akenine-Moller, T., Haines, E. and Hoffman, N., 2018. Real-time rendering. AK Peters/CRC Press. .Foley, van Dam, Feiner, Hughes: Computer Graphics: Principles and Practice Watt: 3D Computer Graphics
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Reinhard Klein
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Computer Graphics (Exam) (KP092501)	1st semester	no semester recommended	8	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Computer Graphics (Lecture)	1st semester	no semester recommended	-	6

Module titel	Foundations of Data Science (Compulsory elective subject)
Identifier	KP20904
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	Data science aims at making sense of big data. To that end various tools have to be understood for helping in analyzing the arising structures. Often data comes as a collection of vectors with a large number of components. To understand their common structure is the first main objective of understanding the data. The geometry and the linear algebra behind them becomes relevant and enlightning. Yet, the intuition from low-dimensional space turns out to be often misleading. We need to be aware of the particular properties of high-dimensional spaces when working with such data. Fruitful methods for the analysis include singular vector decomposition from linear algebra and supervised and unsupervised machine learning. If time permits we also consider random graphs which are the second most used model for real world phenomena.
Learning objective	Mastering mathematical tools for data science.
Requirements	None.
(recommended) Requirements	None.
References	Avrim Blum, John Hopcroft, and Ravindran Kannan (2018+). Foundations of Data Science
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Emmanuel Müller
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Foundations of Data Science (KP2090401)	no semester recommended	no semester recommended	8	6

RWTH AACHEN UNIVERSITY

– Designing Interactive Systems
+ Designing Interactive Systems I (1215698)

Module titel	Designing Interactive Systems I (Compulsory elective subject)
Identifier	1215698
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This class introduces students to human-computer interaction (HCI) and user interface design. It covers the following topics: Fundamental characteristics of human cognition, such as reaction time, rules of perception, and memory performance, Models of interaction between people and their environment, such as affordances, mappings, constraints, slips and mistakes, Milestones in the history of human-computer interaction, Principles of iterative design, User interface prototyping techniques, Golden rules of user interface design, User interface design notations, User studies and evaluation methods
Learning objective	Knowledge: After this class, students will know how user interfaces have developed over the past decades, and what constants of human performance need to be considered when designing them. | Skills: They will be able to apply iterative design, prototyping, and evaluation methods to design usable, appropriate user interfaces in a user-centered fashion. All assignments are group assignments to foster collaboration skills, and project-based to strengthen project planning, conflict management and presentation skills. | Competences: Students learn to think in designers' terms. This is a crucial competence for computer scientists working on user interfaces, a job that requires collaboration in interdisciplinary teams.
Requirements	None.
(recommended) Requirements	None.
References	D. Norman: The Design Of Everyday Things, Basic Books 2002 (required textbook for first few weeks), plus excerpts from A. Dix et al.: Human-Computer Interaction, Prentice-Hall 2004. Shneiderman et al.: Designing The User Interf., Add.-W. 2004; J. Raskin: The Humane Interface, Addison-Wesley 2000
Language	English
Grading	The module examination consists of the following partial qualifications: Written Homework (20 %); Projekt work with presentation (20 %); "Midterm" written exam or oral examination (25 %); Written exam or oral examination (35 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Oliver Borchers
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75

Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Designing Interactive Systems I (121569802)	1st semester	no semester recommended	0	2
Exam Designing Interactive Systems I (121569801)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Designing Interactive Systems I	1st semester	no semester recommended	-	3

+ Ad-Hoc Networks: Architectures and Protocols (6010396)

Module titel	Ad-Hoc Networks: Architectures and Protocols (Compulsory elective subject)
Identifier	6010396
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2010
Valid until	-
Module level	Master
Content	• Principles of ad hoc, heterogeneous, and local area wireless networks • Connectivity and routing in wireless networks • MAC schemes for wireless networks • Energy efficiency of wireless protocols • Wireless network design and standards for modern and emerging applications, e.g. UHD multimedia, IoT, M2M, Industry 4.0, V2X
Learning objective	Specific skills: • Students will understand the fundamental design principles of medium access control and network protocols for ad hoc, heterogeneous and local area wireless networks • Students will be able to describe the functionalities of common wireless medium access control and network protocols and to put them into the context of system design requirements • Students will be able to reason about the design space of feasible wireless communication technologies and network designs for modern and emerging application areas, e.g. broadband multimedia multimedia, IoT, M2M, Industry 4.0, V2X, etc. General skills: • Students will broaden their knowledge of multi-parametric systems design • Students will extend their knowledge on mathematical ;; modelling ;; through abstraction • Students learn to navigate the relevant scientific Reading Liste and review it critically
Requirements	Basic knowledge in the design of communication networks
(recommended) Requirements	Basic knowledge in the design of communication networks
References	# C. Siva Ram Murthy and B.S. Manoj, Ad Hoc Wireless Networks: Architectures and Protocols, Prentice Hall
Language	English
Grading	oral examination (30min) or written examination (90min)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Petri Mähönen
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	90 or 30
Total hours (h)	120
Contact hours (h)	45

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+ Ad-Hoc Networks: Architectures and Protocols (6010396)

Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Ad-Hoc Networks: Architectures and Protocols (601039601)	2nd semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Ad-Hoc Networks: Architectures and Protocols	2nd semester	no semester recommended	-	3

+ Advanced Data Models (1212673)

Module titel	Advanced Data Models (Compulsory elective subject)
Identifier	1212673
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	Advanced concepts and formal methods for data modelling; Data integration methodologies;Semi-structured, object-oriented, and object-relational data models;Semantic data models and ontologies; Mappings between heterogeneous data models;Schema Evolution and Model Management
Learning objective	Knowledge: On successful completion of this module, students should be able to (a) Describe application domains for different modeling languages: (b) Formally analyze semantic data modeling and ontology formalisms; (c) Describe mappings between relational, object-relational, and semi-structured data in heterogeneous information systems; (d) Analyze critically new research directions in data modelling. Skills: They should be able to (1) use advanced software tools for data modeling and data integration; (2) analyze application problems in the modeling of complex distributed, heterogeneous information systems; (3) define mappings in data warehouse and peer-to-peer integration tasks in small to medium complexity projects. Competences: Based on the knowledge and skills acquired, they should be able to (i) advise and help users with their data integration needs and correct errors in existing integrated systems; (ii) identify problems in semantic data modeling and their mapping to relational, object-relational, and semi-structured data, and vice versa.
Requirements	None.
(recommended) Requirements	Knowledge in databases and data modeling (relational and XML) and basic knowledge of first-order logics.
References	M.A. Jeusfeld, M. Jarke, J. Mylopoulos: Metamodeling for Method Engineering, MIT Press, 2009. U. Leser, F. Naumann: Informationsintegration, dpunkt-Verlag, 2006.M. Jarke, M. Lenzerini, Y. Vassiliou, P. Vassiliadis: Fundamentals of Data Warehouse Systems, Springer, 2nd ed., 2003.H. Garcia-Molina, J.D. Ullman, J. Widom: Database Systems - The Complete Book, Pearson Intl., 2nd ed., 2009.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Matthias Jarke
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60

+ Advanced Data Models (1212673)

Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Data Models (121267302)	1st semester	no semester recommended	0	1
Exam Advanced Data Models (121267301)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Data Models	1st semester	no semester recommended	-	3

+ Advanced Internet Technology (1215688)

Module titel	Advanced Internet Technology (Compulsory elective subject)
Identifier	1215688
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Introductory courses in communication systems deal with the classic communication principles of the Internet. These communication techniques are still in use, but are not able to cope with all the requirements of modern networks. This course gives an introduction into advanced communication paradigms that build upon the existing Internet technology: • Realizing scalable applications and communication: Peer-to-Peer systems and Cloud Computing • Integration of devices with restricted resources into the Internet: Cyber-physical Systems and the Internet of Things • Realization of adaptive communication: Software Defined Networking and Quality of Service
Learning objective	**Knowledge**: On successful completion of this module, students should be able to: • understand the restrictions of classical communication principles in the modern Internet • describe basic principles for realizing scalable, adaptive and resource constraint communication **Skills**: They should be able to: • identify sources of problems of classical communication protocols in modern communication systems • apply algorithms for scalable, adaptive and resource constraint communication **Competences**: Based on the knowledge and skills acquired they should be able to: • analyze the applicability of solutions for scalable, adaptive and resource constraint communication to future mobile Internet scenarios methodically • identify possibilities of evolving modern communication systems
Requirements	None.
(recommended) Requirements	Basic knowledge in data communication and security is helpful.
References	• Vorlesungsfolien / Lecture Slides • Steinmetz, Wehrle (Eds.): Peer-to-Peer Systems and Applications, Springer, 2005 • Karl, Willig: Protocols and Architectures for Wireless Sensor Networks, Wiley, 2005 • Weitere Spezialliteratur wird in den Vorlesungsfolien bekannt gegeben
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Klaus Wehrle
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)

+ Advanced Internet Technology (1215688)

Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Internet Technology (121568802)	5th semester	no semester recommended	0	1
Exam Advanced Internet Technology (121568801)	5th semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Internet Technology	5th semester	no semester recommended	-	3

+ Advanced Methods of Cryptography (6010414)

Module titel	Advanced Methods of Cryptography (Compulsory elective subject)
Identifier	6010414
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Summer semester 2010
Valid until	-
Module level	Master
Content	• Advanced public key encryption • Side channel attacks • Cryptographic hash functions • Identification and entity authentication • Elliptic curve cryptography • Quantum cryptography
Learning objective	Students will acquire advanced knowledge about cryptographic protocols and their foundation in mathematics. At the end of the module students are able • to understand corresponding standards, modern implementations and applications. • to select appropriate cryptosystems for different types of applications • to compose tailored cryptosystems by using building blocks proposed by standardization bodies. • to apply and implement recent elliptic curve encryption and decryption to practical systems, particularly smart cards.
Requirements	-
(recommended) Requirements	Basic knowledge of probability theory and number theory. Knowledge of public key encryption as provided in the lecture “Cryptography”.
References	• Menezes, A.J., van Oorschot, P.C., Vanstone, S.A.: Handbook of Applied Cryptography. CRC Press, Boca Raton, 1996. • Schneier, B.: Applied Cryptography (2nd ed.). Wiley, New-York, 1996. • Trappe, W., Washington, L.C.: Introduction to Cryptography with Coding Theory. Prentice • Hall, Upper Saddle River, 2002. A list of further readings will be issued at the beginning of the lecture
Language	English
Grading	Written examination (90min) or oral examination (30min)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Rudolf Mathar
ECTS Credits	8
Contact time (WSH)	4
Examination duration (min)	90 or 30
Total hours (h)	240
Contact hours (h)	60

+ Advanced Methods of Cryptography (6010414)

Self-study hours (h)	180

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Advanced Methods of Cryptography (601041401)	1st semester	no semester recommended	8	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Advanced Methods of Cryptography	1st semester	no semester recommended	-	4

+ Advanced Process Mining (1220136)

Module titel	Advanced Process Mining (Compulsory elective subject)
Identifier	1220136
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	Process mining provides a new means to improve processes in a variety of application domains. There are two main drivers for this new technology. On the one hand, more and more events are being recorded thus providing detailed information about the history of processes. On the other hand, in most organizations, there is a need to improve process performance (e.g. to reduce costs and flow time) and compliance (e.g. to avoid deviations or risks). Process mining bridges the gap between model-based process analyses (e.g., simulation, model checking, and classical BPM techniques) and data-oriented techniques (e.g. data mining techniques like classification, clustering, and regression). Process mining techniques can be applied in a variety of domains. Written homework (PM Assignment 1) includes Hands-on experience with process mining and includes evaluating process mining techniques and the effect of noise. Written homework (PM Assignment 2) includes Real-world process mining based on real-life event log.
Learning objective	After taking this course students should: • have a detailed understanding of the entire process mining spectrum and be able to relate process mining techniques to other analysis techniques (data mining, model checking, simulation, machine learning, etc.), • understand the positioning of process mining in the context of data science, process management and "big data", • be able to apply a range of process mining techniques and use tools such as RapidMiner, ProM, and Disco, • be able to design analysis workflows and execute them on concrete practical datasets (e.g., using RapidMiner and ProM), • be able to conduct experiments to investigate the influence of noise (infre-quent/deviating behavior) on the process mining results, • be able to read formal descriptions of process mining techniques and reason about their properties, • understand the intricate relation between observed behavior (e.g., events logs in XES or MXML format) and modeled behavior (e.g., Petri nets with an initial and final marking), • understand and apply advanced process discovery techniques using language-based regions (ILP miner), • be able to discuss all four conformance dimensions (replay fitness, precision, generali-zation, and simplicity), provide metrics for these dimensions, and apply conformance checking using models and logs, • be able to reason about the strengths and weaknesses of existing process mining algo-rithms and critically evaluate new ones, • understand and create alignments as a tool for conformance checking and other types of analysis that require the mapping of observed behavior onto modeled behavior, • understand the limitations of process techniques in terms of computation time, memory use, and data requirements, • be able to decompose large process mining problems (discovery and conformance checking) into smaller ones (using valid decompositions), • understand the relation between the results of decomposed process mining and non-decomposed process mining (e.g., what properties are preserved and what guarantees can be given), and • be able to conduct real-world process mining projects using real data and imprecise questions from stakeholders.
Requirements	None.
(recommended) Requirements	• Basic Knowledge of Process Mining Concepts• Basic Knowledge of Discrete Mathematics• Basic Knowledge of Petri nets
References	Examples of mandatory papers that need to be studied in detail: J.M.E.M. van der Werf, B.F. van Dongen, C.A.J. Hurkens, and A. Serebrenik. Process Discovery using Integer Linear Programming. Fundamenta Informaticae, 94: 387-412, 2010. W.M.P. van der Aalst, A. Adriansyah, and B. van Dongen. Replaying History on Process Models for Conformance Checking and Performance Analysis. WIREs Data Mining and Knowledge Discovery, 2(2):182-192, 2012. Selected parts of A. Adriansyah, B. van Dongen, and W.M.P. van der Aalst. Memory-Efficient Alignment of Observed and Modeled Behavior. BPM Center Report BPM-13-03, 2013 W.M.P. van der Aalst. Decomposing Petri Nets for Process Mining: A Generic Ap-proach. Distributed and Parallel Databases, 31(4):471-507, 2013.

+ Advanced Process Mining (1220136)

	The textbook "W.M.P. van der Aalst. Process Mining: Data Science in Action. Springer-Verlag, Berlin, 2016" (http://springer.com/9783662498507) is advised as background information. Additional background information (optional, just for context or clarification): W.M.P. van der Aalst. Process Mining. Communications of the ACM, 55(8):76-83, 2012. IEEE Task Force on Process Mining. Process Mining Manifesto. 2011. http://www.win.tue.nl/ieeetfpm/. A. Rozinat and W.M.P. van der Aalst. Conformance Checking of Processes Based on Monitoring Real Behavior. Information Systems, 33(1):64-95, 2008. W.M.P. van der Aalst and C. Stahl. Modeling Business Processes: A Petri Net Oriented Approach. MIT press, Cambridge, MA, 2011. R. Lorenz, J. Desel, G. Juhás. Models from Scenarios. T. Petri Nets and Other Models of Concurrency 7: 314-371, 2013. A. Adriansyah. Aligning Observed and Modeled Behavior. PhD Thesis Technische Universiteit Eindhoven, 2014.
Language	English
Grading	The module examination consists of the following partial qualifications: Written homework (40 %); Written exam or oral examination (60 %). Students must pass all parts of the examination individually to pass the module. It is not possible to transfer parts of the
Miscellaneous	-
Module coordinator	Universitätsprofessor Professor h. c. Dr. h. c. Dr. ir. Wil van der Aalst
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	120
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Advanced Process Mining (Exercise) (122013602)	no semester recommended	no semester recommended	0	2
Advanced Process Mining (Written Exam) (122013601)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Advanced Process Mining (Lecture)	no semester recommended	no semester recommended	-	3

+ Algorithmic Game Theory (1212326)

Module titel	Algorithmic Game Theory (Compulsory elective subject)
Identifier	1212326
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	1. Introduction to game theory; 2. Complexity of game theoretic solution concepts; 3. Congestion and potential games; 4. Price of anarchy; 5. Algorithmic aspects of mechanism design
Learning objective	Knowledge: At the end of this course, the students should be able to describe and define basic game theoretic notions and solution concepts, to explain the computational complexity for problems arising in game theory and mechanism design, and to explain algorithms for these problems. | Skills: The students should be able to critically discuss common game theoretical assumptions, to analyze equilibria and other solution concepts, and to design and analyse algorithms for computing solution concepts. | Competences: The students should be able to model strategic situations using game theoretic notions and concepts and apply algorithmic methods resolving the game theoretic problems.
Requirements	Basic knowledge about algorithms, discrete structures, probability theory (stochastic). Students must pass the exercises to be admitted to the examination. Details will be provided in the lecture.
(recommended) Requirements	Basic knowledge about algorithms, discrete structures and probability theory (stochastic).
References	N. Nisan, T. Roughgarden, E. Tardos, V. Vazirani. Algorithmic Game Theory, Cambridge University Press, 2007. | T. Roughgarden. Selfish Routing and the Price of Anarchy. MIT Press, 2005. | A. Mas-Colell, M.D. Whinston, and J.R. Green. Microeconomic Theory. Oxford University Press, 1995. | M.J. Osborne. An Introduction to Game Theory. Oxford University Press. 2004.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Gerhard Woeginger
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Algorithmic Game Theory (1212326)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Algorithmic Game Theory (121232602)	1st semester	no semester recommended	0	2
Exam Algorithmic Game Theory (121232601)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Algorithmic Game Theory	1st semester	no semester recommended	-	3

+ Algorithmic Differentiation (1221328)

Module titel	Algorithmic Differentiation (Compulsory elective subject)
Identifier	1221328
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	Grundlagen des Algorithmischen Differenzierens; Kombinatorische Probleme in AD (Kompression von Ableitungstensoren, Eliminationstechniken für Jacobimatrizen, Datenflussinversion) und Relevanz für Maschinelles Lernen; AD für numerische Algorithmen; AD von numerischen Algorithmen; Auswahl aktueller Themen in AD; Die Studierenden verfügen über Verständnis numerischer und kombinatorischer Probleme im algorithmischen Differenzierens vor dem Hintergrund von Anwendungen in den computergestützten Natur- und Ingenieurwissenschaften und im Maschinellen Lernen; die Fähigkeit der Implementierung dieser Methoden mithilfe der Programmiersprache C++; die Fähigkeit der effektiven Verwendung von AD Softwarebibliotheken zur Implementierung der besprochenen Methoden vor dem Hintergrund praktisch relevanter Simulations- und Optimierungsprobleme.
Learning objective	-
Requirements	None.
(recommended) Requirements	None.
References	Naumann: The Art of Differentiating Computer Programs. SIAM 2012; Griewank, Walther: Evaluating Derivatives. SIAM 2008.
Language	English
Grading	Written exam (100 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Uwe Naumann
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Algorithmic Differentiation (1221328)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Excercise Algorithmic Differentiation (122132802)	1st semester	no semester recommended	0	2
Exam Algorithmic Differentiation (122132801)	no semester recommended	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Algorithmic Differentiation	no semester recommended	no semester recommended	-	2

+ Big Data Analytics (KP20911)

Module titel	Big Data Analytics (Compulsory elective subject)
Identifier	KP20911
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	In our lectures we cover basic concepts in the field of data analysis. The techniques for the analysis of large data sets have a large impact in many applications. The range of applications is broad and includes both industrial and scientific data. In both areas there is the necessity of extracting interesting patterns from very large datasets. In our courses we introduce the processing of large volumes of data as a precondition for quick and efficient analyses as well as the study of fundamental data mining techniques applicable to different domains. The lecture „Big Data Analytics“ will focus on data mining algorithms for knowledge discovery and covers the main steps of the Knowledge Discovery in Databases (KDD) process. We will introduce the basic data mining challenges and propose different algorithmic solution from each data mining sub-area. Furthermore, we will present basic evaluation methods which can be used to assess the quality of data mining results in various application areas.
Learning objective	Professional skills: • Classification and implementation of the steps of knowledge discovery in databases (KDD) process; • especially handling the practical and theoretical basics in the fields of statistics, clustering, classification and frequent itemset mining. Soft skills: • communicational skills (oral and written presentation, defense of solutions), • organizational skills (time management and self-organization, creativity), • social skills (discussion and division of work in smaller groups)
Requirements	None.
(recommended) Requirements	None.
References	• Jiawei Han, Micheline Kamber, Jian Pei: Data Mining: Concepts and Techniques, 3. Auflage, Morgan Kaufmann Publishers, 2011. • Mohammed J. Zaki, Wagner Meira JR.:Data Mining and Analysis, Fundamental Concepts and Algorithms Campridge University Press 2014. • Jure Leskovec, Anand Rajaraman, Jeffrey David Ullman: Mining of Massive Datasets, 2. Auflage (2014) (online PDF). • Pang-Ning Tan, Michael Steinbach, Vipin Kumar, Addison-Wesley: Introduction to Data Mining, 2006. • Martin Ester, Jörg Sander Knowledge Discovery in Databases:, Springer 2000.
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Professor Dr. rer. nat. Emmanuel Müller
ECTS Credits	6

+ Big Data Analytics (KP20911)

Contact time (WSH)	4
Examination duration (min)	120
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Big Data Analytics (Exam) (KP2091101)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Big Data Analytics (Lecture)	no semester recommended	no semester recommended	-	4

+ Communication Protocols (6017116)

Module titel	Communication Protocols (Compulsory elective subject)
Identifier	6017116
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	The course starts with a comprehensive review of relevant topics in communication networks to build the foundation for further studies on specific protocol designs and their practical implications. In particular, the course initially reviews: • ISO/OSI layer model • MAC layer protocol principles • Routing • TCP/IP basics: addressing, congestion control After reviewing the fundamentals, advanced topics relevant to contemporary communication protocols will be studied, e.g.: • Core Internet protocols, e.g. HTTP, DNS, SIP/RTP, SMTP, etc. • Advanced congestion control, TCP in heterogeneous environments • Protocols supporting Cloud and data centre services, e.g. content distribution, caching, etc. • High-performance algorithm design, i.e. hardware-customized algorithms, trade off considerations
Learning objective	Specific skills: • Students will gain advanced knowledge of current technologies in the area of communication networks • Students will understand the implications of large distributed systems on communication protocol design • Students will be able to explain the functionality and design principles of selected core communication protocols, and put them into the context of modern data networks General skills: • Students will become familiar with reading and navigating the modern technical Reading Liste in the field, including communication standards • Students will learn to consider practical engineering tradeoffs in protocol design • Students will extend their knowledge of mathematical modelling of distributed systems • Students will learn the basic design principles of complex distributed systems
Requirements	-
(recommended) Requirements	Basic knowledge in the design of communication networks and the TCP/IP stack for internetworking.
References	James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, Addison Wesley • A. Leon-Garcia and I. Widjaja, Communication Networks, McGraw Hill, 2003.
Language	English
Grading	Written examination (90min) or oral examination (30min).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Petri Mähönen
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	90 oder 30
Total hours (h)	120
Contact hours (h)	45

+ Communication Protocols (6017116)

Self-study hours (h)	75

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Communication Protocols (601711601)	1st semester	no semester recommended	4	-

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Communication Protocols	1st semester	no semester recommended	-	3

+ Communication Systems Engineering (1212349)

Module titel	Communication Systems Engineering (Compulsory elective subject)
Identifier	1212349
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This lecture addresses the foundations and technologies required in the engineering of modern communication systems: • Protocol Design: basic methods for designing communication protocols • ;Implementation: tools and technologies for implementing communication systems in both kernel space and user space • Verification and Testing: approaches to ensure the correct behavior of a protocol implementation • Evaluation by discrete event simulation (modeling, validation, parameter studies) • Internet-scale evaluation by measurements.
Learning objective	**Knowledge**: On successful completion of this module, students should be able to: • understand the foundations of protocol engineering • describe the different concepts of performance evaluation **Skills**: They should be able to: • analyze the results of a performance evaluation study • propose enhancements for existing communication systems **Competences**: • Based on the knowledge and skills acquired they should be able to: • design and develop novel communication systems and evaluate their performance.
Requirements	None.
(recommended) Requirements	Basic knowledge in data communication and operating systems. Knowledge in C/C++ are helpful.
References	Lecture slides; within the slides further literature is cited.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Klaus Wehrle
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Communication Systems Engineering (1212349)

Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Communication Systems Engineering (121234901)	no semester recommended	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture/Exercises Communication Systems Engineering	no semester recommended	no semester recommended	-	4

+ Cryptography (6011250)

Module titel	Cryptography (Compulsory elective subject)
Identifier	6011250
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2009
Valid until	-
Module level	Bachelor
Content	# Klassische Kryptographie: Kryptoanalyse klassischer Chiffren, Frequenzanalyse, allgemeine Angriffsarten # Entropie und perfekte Sicherheit: Äquivokation, Redundanz, One-time-pad Schnelle Blockchiffren: DES; AES, IDEA, Operationsmodi # Zahlentheoretische Referenzprobleme: Primzahltests, Faktorisierung ganzer Zahlen, erweiterter Euklidischer Algorithmus, Chinesischer Restsatz, diskreter Logarithmus, Diffie-Hellman-Schlüsselaustausch, Shamirs No-key-Protokoll # Public-key-Verschlüsselung: grundlegende Konzepte, RSA Verschlüsselung, Sicherheit von RSA, Aspekte zur Implementation # Authentifizierung und digitale Signaturen: Challenge-and-response, RSA-Authentifizierung und digitale Signaturen
Learning objective	After successful participation in the course lectures the students will have acquired a basic knowledge in modern methods of encryption and authentication as well as in the underlying protocols and mathematical foundations. Students will be able to transfer this knowledge to practical systems. Students will have acquired skills to select appropriate cryptosystems for different types of applications.
Requirements	-
(recommended) Requirements	-
References	# Menezes, A.J., van Oorschot, P.C., Vanstone, S.A.: Handbook of Applied Cryptography. CRC Press, Boca Raton, 1996. # Schneier, B.: Applied Cryptography (2nd ed.). Wiley, New-York, 1996. # Trappe, W., Washington, L.C.: Introduction to Cryptography with Coding Theory. Prentice Hall, Upper Saddle River, 2002.
Language	English
Grading	Oral examination (30 min) or written examination (90 min)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Rudolf Mathar
ECTS Credits	3
Contact time (WSH)	3
Examination duration (min)	90 or 30
Total hours (h)	90
Contact hours (h)	45
Self-study hours (h)	45

+ Cryptography (6011250)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Cryptography (601125001)	6th semester	no semester recommended	3	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Cryptography	6th semester	no semester recommended	-	3

+ Data Science and Big Data (KP20926)

Module titel	Data Science and Big Data (Compulsory elective subject)
Identifier	KP20926
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	The course offers an in-depth knowledge of different aspects of big data analytics and systems, including algorithmic techniques for analysing structured and unstructured data that cannot be stored in a single computer because it has enormous size and/or continuously arrives with such a high rate that requires immediate processing. In addition to the algorithmic aspects, distributed big data processing and database systems will be presented and applied. Topics include similarity search, synopses for massive data, mining massive graphs, classical data mining tasks for massive data and/or data streams, architectures and protocols for big data systems, distributed batch (Hadoop) and stream (Storm) processing systems, non-standard databases for big data (Cassandra).
Learning objective	Knowledge: Architectures and protocols for big data systems, distributed batch and stream processing systems, non-standard databases for big data, databases for structured data, similarity search, synopses for massive data, classical data mining tasks for massive data and/or data streams, mining massive graphs, applications. | Skills: Programming for distributed systems like Apache Spark, Storm, et al. Reasoning about formal concepts, formal analysis of algorithms for data science and big data. | Competences: Implementing sublinear and subquadratic practical sequential and distributed algorithms on distributed platforms. Appropriate choice of algorithms for distributed settings based on formal analysis.
Requirements	None.
(recommended) Requirements	Knowledge of the modules “Intelligent Learning and Analysis Systems: Machine Learning” and “Intelligent Learning and Analysis Systems: Data Mining and Knowledge Discovery”.
References	N. Marz and J. Warren: Big Data. Principles and best practices of scalable realtime data systems. Manning Pubn, 2014; T. White: Hadoop The Definitive Guide. O’REILLY, 2012; A. Rajaraman and J.D. Ullman.: Mining of Massive Datasets. Cambridge University Press, 2011; G. Cormode, M. Garofalakis, P.J. Haas, and C. Jermaine: Synopses for Massive Data: Samples, Histograms, Wavelets, Sketches. Foundations and Trends in Databases 4(1-3): 1-294 (2012)
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Stefan Wrobel
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-30 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Data Science and Big Data (KP20926)

Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Data Science and Big Data (Exam) (KP2092601)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Data Science and Big Data (Lecture)	no semester recommended	no semester recommended	-	4

+ The Art of Cryptography (KP20903)

Module titel	The Art of Cryptography (Compulsory elective subject)
Identifier	KP20903
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	Possible topics are protocols for secure communication, zero knowledge, security reductions, secure electronic elections, secure electronic cash, secure electronic passports.
Learning objective	Knowledge: Structure of some complex real-world communication protocol, attack scenarios, security problems and formulation of security requirements. Connections to security of the involved primitives. Skills: Understanding of secure cryptographic schemes and their security. Basic assessment of known state of the art results of the considered schemes. Competences: Evaluation of secure cryptographic schemes, in particular communication protocols.
Requirements	None.
(recommended) Requirements	Foundational Knowledge about Cryptography.
References	-
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Dr. rer. nat. Michael Nüsken
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	120
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ The Art of Cryptography (KP20903)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
The Art of Cryptography (KP2090301)	1st semester	1st semester	8	6

+ Introduction to Algorithmic Differentiation (1221327)

Module titel	Introduction to Algorithmic Differentiation (Compulsory elective subject)
Identifier	1221327
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Bachelor/Master
Content	• Mathematische Grundlagen des Algorthimischen Differenzierens (AD) • Algorithmische Tangenten und Adjungierte und Verbindung zu back propagation im Maschinellen Lernen • Ableitungscode erster und höherer Ordnung • Einführung in das AD Werkzeug dco/c++ • Manuelle Implementierung von Ableitungscode • Grundlagen der Quellcodetransformation: Parser; Attributgrammatiken und syntaxorientierte Quellcodetransformation • Ableitungscode per Quellcodetransformation • AD-spezifische Datenflussanalyse
Learning objective	Die Studierenden verfügen über • Verständnis grundlegender Methoden des numerischen und algorithmischen Differenzierens vor dem Hintergrund von Anwendungen in den computergestützten Natur- und Ingenieurwissenschaften und im Maschinellen Lernen • die Fähigkeit der Implementierung dieser Methoden mithilfe der Programmiersprache C++ • die Fähigkeit der effektiven Verwendung von AD Softwarebibliotheken zur Lösung praktisch relevanter Simulations- und Optimierungsprobleme
Requirements	None.
(recommended) Requirements	None.
References	Naumann: The Art of Differentiating Computer Programs. SIAM 2012. Griewank, Walther: Evaluating Derivatives. SIAM 2008.
Language	English
Grading	Written exam (100 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Uwe Naumann
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	120
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Introduction to Algorithmic Differentiation (1221327)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Introduction to Algorithmic Differentiation (122132702)	1st semester	no semester recommended	0	1
Exam Introduction to Algorithmic Differentiation (122132701)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Introduction to Algorithmic Differentiation	1st semester	no semester recommended	-	3

+ Introduction to Numerical Methods and Software (1220996)

Module titel	Introduction to Numerical Methods and Software (Compulsory elective subject)
Identifier	1220996
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2019
Valid until	-
Module level	-
Content	Computer arithmetic, condition, error analysis, linear systems, nonlinear systems, convex optimization, algorithmic differentiation, numerical integration, differential equations, Eigenproblems, interpolation and approximation.
Learning objective	Knowledge: understanding of fundamental numerical methods. Skills: ability to implement numerical algorithms. Competences: mathematical and computer science aspects of numerical methods
Requirements	None.
(recommended) Requirements	None.
References	Heath: Scientific Computing. An Introductory Survey. McGraw-Hill Knorrenschild: Numerische Mathematik. Eine beispielorientierte Einführung. Hanser
Language	English
Grading	Written exam or oral examination (100 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Uwe Naumann
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Numerical Methods and Software (Exam) (122099601)	no semester recommended	no semester recommended	6	0

+ Introduction to Numerical Methods and Software (1220996)

Introduction to Numerical Methods and Software (Exercise) (122099602)	no semester recommended	no semester recommended	0	2

▲Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Numerical Methods and Software (Lecture)	no semester recommended	no semester recommended	-	3

+ Embedded Systems (1215690)

Module titel	Embedded Systems (Compulsory elective subject)
Identifier	1215690
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Embedded systems control many things in our daily life. Energy-efficient refrigerators, elevator controls, and advanced driver assistance systems are just some examples. Embedded systems also control processes in industrial environments and are used to detect and prevent system failures. This lecture gives a general introduction to the topic of embedded systems. It introduces basic concepts and points out important differences to “normal” computer systems. This lecture prepares students for advanced lectures of the Embedded Software Laboratory that cover safety, reliability, formal methods and dynamic systems in detail. This lecture is targeted at all students that do not want to limit themselves to understanding PCs but also want to know how, for example, engine control units and production control systems work. Topics covered in this lecture are: Microcontroller, Programmable logic controllers (PLCs, PLC programming languages, Real-time requirements, Real-time operating systems, Characteristics of embedded software design, Intra vehicle communication (e.g., CAN bus), Teasers of advanced lectures of the embedded software laboratory, The lecture will be held in German with English slides.
Learning objective	Knowledge: Knowledge and confidence in modern software techniques for embedded systems | Skills: Ability to apply a model-based quality-oriented approach for the design of embedded software | Competences: Sensibility for special qualitative requirements for the design of embedded software
Requirements	None.
(recommended) Requirements	Knowledge of “Foundations of Technical Computer Science”.
References	Slides of the lecture, script and the following books: Marwedel: Eingebettete Systeme. 2003 | Bass, Clements: Software Architecture in Practice. | Douglass: Real-time UML
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Stefan Kowalewski
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60

+ Embedded Systems (1215690)

Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Embedded Systems (121569002)	1st semester	no semester recommended	0	1
Exam Embedded Systems (121569001)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Embedded Systems	1st semester	no semester recommended	-	3

+ Functional safety and system dependability (1212353)

Module titel	Functional safety and system dependability (Compulsory elective subject)
Identifier	1212353
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Basic terms (damage, risik, safety, reliability, availability, etc.) | Reference model reliability (error prevention vs. Fault tolerance, defect-faultbreakdown) | Design patterns for reliability (Redundancy, Replication) | Analysis methods for Reliability (RBDs, fault trees) | Hazard and risk analysis, IEC 61508
Learning objective	Knowledge: Knowledge of terminology, criteria, analysis and design methods for safety and reliability-related systems | Skills: Capability to specify safety- and reliability-relevant requirements, verify them and take them into consideration when designing such systems | Competences: Ability to create sensitivity for safety and reliability-related design issues
Requirements	None.
(recommended) Requirements	Basic knowledge of Embedded Systems.
References	Slides of the lecture, script and the following books: Storey: Safety-critical computer systems. Prentice Hall, 1996 | N. Leveson: Safeware. Addison-Wesley, 2001 | J. Barnes: High integrity software. Addison-Wesley, 2003 | K. Simpson, D. Smith: Functional Safety. Elsevier, 2004 | Birolini: Reliability Engineering. Springer, 2004. | S. Montenegro: Safe and fault-tolerant controls. Hanser, 1999.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Stefan Kowalewski
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Functional safety and system dependability (1212353)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Functional safety and system dependability (121235302)	1st semester	no semester recommended	0	1
Exam Functional safety and system dependability (121235301)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Functional safety and system dependability	1st semester	no semester recommended	-	3

+ High-Performance Computing (1215720)

Module titel	High-Performance Computing (Compulsory elective subject)
Identifier	1215720
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	• Characteristics of micro architectures • Parallel computer architectures • Network topologies • Blocking algorithms to exploit data locality in deep memory hierarchies • Design principles of parallel algorithms • Modelling parallelism (speedup, efficiency, Amdahl) and performance • Introduction to parallel programming • Further selected topics
Learning objective	Acquisition of knowledge and skills as follows: • Comprehension of the main parallel computer architectures • Knowledge on basic design methodologies for data-local serial and parallel algorithms • Skills to apply basic methods for the analysis of runtime behavior of parallel algorithms • Comprehension of elementary operations in parallel programming
Requirements	None.
(recommended) Requirements	Skills in the main concepts of imperative and object-oriented programming languages, as well as elementary programming techniques in these languages (Lecture on Programming)
References	PDF-Dateien der Folien und Übungen (zum Download), sowie: • G. Hager and G. Wellein: Introduction to High Performance Computing for Scientists and Engineers. CRC Computation Science Series, 2010. ISBN: 978-1-4398-1192-4. • J. Hennessy and D. Patterson: Computer Architecture. A Quantitative Approach. Morgan Kaufmann Publishers, Elsevier, 2011. ISBN: 978-0123838728.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Modulangebotsorganisator: Modulangebotsverantwortlicher InformatikModellierungsteamverantwortlicher: Dr. rer. nat. Katja PetzoldtModulverantworlicher: Universitätsprofessor Dr. rer. nat. Matthias Müller
ECTS Credits	6
Contact time (WSH)	3
Examination duration (min)	0
Total hours (h)	180

+ High-Performance Computing (1215720)

Contact hours (h)	45
Self-study hours (h)	135

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam High-Performance Computing (121572001)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture + Exercise High-Performance Computing	1st semester	no semester recommended	-	3

+ Implementation of Databases (1215692)

Module titel	Implementation of Databases (Compulsory elective subject)
Identifier	1215692
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	The module discusses the key aspects of the implementation of database systems. This includes an introduction of basic architectures (e.g. layered architecture) as well the procedures necessary for solving individual tasks (especially query processing and transaction management). The concepts of implementation will be applied to classical relational model as well as to more recent data models (distributed, object-oriented, deductive, search engines). In addition to the necessary theoretical background practical concepts will be introduced that allow database administrators the efficient tuning of databases.
Learning objective	Knowledge: Students will understand database architectures, query processing and optimization algorithms, transaction management concepts including recovery algorithms and their principles, and administration of databases. Competencies and skills: Students will be able to apply knowledge in these domains in practical problems of structuring a data management system, optimizing user queries, choosing appropriate concurrency control and recovery methods. In team exercises, students analyse and optimize database structures and functionalities, and present their handed-in solution in front of the class. Benefits for future professional life: Professional knowledge about evaluating, administrating and tuning existing databases as well as a solid understanding of information system architectures in modern businesses.
Requirements	None.
(recommended) Requirements	None.
References	D.E. Shasha: Database Tuning - A Principled Approach. Prentice Hall, 1992 Elmasri, S. Navathe: Fundamentals of Database Systems, Addison-Wesley, 4. Aufl. 2003. T. Härder, E. Rahm: Datenbanksysteme – Konzepte und Techniken der Implementierung. Springer 1999. G. Vossen: Datenmodelle, Datenbanksprachen und Datenbank-Management-Systeme. Addison-Wesley, 4. Aufl. 2004.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Matthias Jarke
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Implementation of Databases (1215692)

Contact hours (h)	60
Self-study hours (h)	120

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Implementation of Databases (121569202)	1st semester	no semester recommended	0	1
Exam Implementation of Databases (121569201)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Implementation of Databases	1st semester	no semester recommended	-	3

RWTH AACHEN UNIVERSITY

+ Intelligent Learning and Analysis Systems: Data Mining & ...

Module titel	Intelligent Learning and Analysis Systems: Data Mining & Knowledge Discovery (Compulsory elective subject)
Identifier	KP20927
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	This module focuses on algorithms for discovering knowledge in large databases and on their formal and technical properties (e.g. scalability). We will get to know scalable variants of the decision tree methods that we have been looking at in the Machine Learning module, and discover algorithms for new Data Mining tasks that we have not been looking at there, in particular clustering, association rule discovery, subgroup discovery, discovery from spatial and geographic data, analysis algorithm for text and web documents, visualization options for data analysis. We will mostly be focusing on practical and algorithmic aspects which can be tried out with popular Data Mining packages, but will also have a chance to look at some of the theory behind the algorithms.
Learning objective	Knowledge: • Types of learning and analysis tasks, • scalability techniques, • descriptive data mining methods, • association rules, • subgroups, • clustering, • pre- and postprocessing, • data storage (data warehouses, OLAP), special data types (spatial, network, text, multimedia data), • interactive and visual systems. Skills: • Reasoning about formal concepts, formal analysis of algorithms for data mining. • Usage of standard toolboxes for data mining. Competences: • At the end of the module, students will be capable of choosing appropriate methods and systems for particular pattern discovery applications and use them to arrive at convincing results, and will know where to start whenever adaptation or further development of algorithms and systems is necessary.
Requirements	None.
(recommended) Requirements	Prior knowledge of probability theory, linear algebra, formal aspects of algorithms, artificial intelligence, information systems and databases.
References	Ian Witten, Eibe Frank, Data Mining, Morgan Kauffmann,2000; Jiawei Han, Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2000
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	-

+ Intelligent Learning and Analysis Systems: Data Mining & ...

ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Intelligent Learning and Analysis Systems: Data Mining & Knowledge Discovery (Exam) (KP2092701)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Intelligent Learning and Analysis Systems: Data Mining & Knowledge Discovery (Lecture)	no semester recommended	no semester recommended	-	4

+ Introduction to Bioinformatics (1211903)

Module titel	Introduction to Bioinformatics (Compulsory elective subject)
Identifier	1211903
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Genome and Sequences (DNA sequences, Algorithms for sequence comparison, Sequence databases, Patterns and motifs, Phylogenetic trees); Proteins and Structures (3D modelling, Protein databases, Protein structure analysis and prediction); Protein Expression and Function (DNA chip technology, Gene expression analysis, Clustering, Proteomics); Pathways and Systems (Metabolic networks, Pathway analysis, Cell simulation).
Learning objective	Knowledge: Students learn the application of computer science in the life sciences in the following areas: Alignments and phylogenetic trees, structural bioinformatics, proteomics and systems biology. | Skills: Modelling natural phenomena, understanding probabilistic approaches. | Competences: Understanding of trade-offs and limitations of algorithmic approaches. In-depth analytical and logical skills in an important field of application. | The lecture promotes interdisciplinary thinking: understanding of informatics methods and solutions in biology, especially molecular biology.
Requirements	None.
(recommended) Requirements	Foundational Knowledge of Computer Science.
References	Reinhard Rauhut, Bioinformatik. Sequenz - Struktur - Funktion. Wiley-VCH, 2001; Richard Durbin, A. Krogh, G. Mitchison, S. Eddy, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Cambridge University Press, 1999; Minoru Kanehisa, Post-Genome Informatics. Oxford University Press, 2000.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Thomas Berlage
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

+ Introduction to Bioinformatics (1211903)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Introduction to Bioinformatics (121190302)	1st semester	no semester recommended	0	1
Exam Introduction to Bioinformatics (121190301)	1st semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Introduction to Bioinformatics	1st semester	no semester recommended	-	2

+ IT-Security 1 - Cryptographic Basics and Network Security ...

Module titel	IT-Security 1 - Cryptographic Basics and Network Security (Compulsory elective subject)
Identifier	1211901
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	The lecture consists of two parts. The first part covers the cryptographic basics including: Symmetric Encryption, Integrity protection, Asymmetric Encryption, Digital Signatures, Certificates and Public Key Infrastructures, and Authentication and Key Agreement. The second part is dedicated to Network Security including Kerberos, IPsec, TLS protocol, SSH, DNS Security, Email Security, and Phishing Attacks.
Learning objective	Knowledge: On successful completion of this module, students should be able to define the cryptographic primitives symmetric / asymmetric encryption, digital signatures, cryptographic hash function, and message authentication codes. They should be able to explain the security features offered by the latest versions of the most important security protocols operating on the TCP/IP stack (IPsec, TLS, SSH, DNSsec, PGP) and describe known attacks against these security protocols. | Skills: the students should be able to select and apply the appropriate cryptographic primitives in different application scenarios. They should be able to select the appropriate security protocols in a given scenario and configure the appropriate options for the selection of the appropriate cryptographic building blocks applied within the studied protocols. | Competences: Based on the knowledge and skills acquired they should be able to identify the security requirements and adequate security mechanisms in different areas of application. In addition they should be able to identify potential weaknesses in security protocols that have not been studied in detail within the lecture and be able to suggest fixes to the identified weaknesses. Finally they should be able to assess the severity of new attacks against security protocols and cryptographic primitives.
Requirements	None.
(recommended) Requirements	Basics of Data Communication and Modular Arithmetic.
References	• Introduction to Cryptography and Network Security, Forouzan, Mc Graw-Hill International • Network Security: Private Communication in a Public World, Kaufmann, Perlman, and Speciner, Prentice Hall • Cryptography and Network Security - Principles and Practice, Stallings, Prentice Hall
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessorin Dr.-Ing. Ulrike Meyer
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)

+ IT-Security 1 - Cryptographic Basics and Network Security ...

Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture IT-Security 1 (121190102)	1st semester	no semester recommended	0	1
Exam IT-Security 1 (121190101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture IT-Security 1	1st semester	no semester recommended	-	3

+ IT-Security 2 - Computer Security (1211900)

Module titel	IT-Security 2 - Computer Security (Compulsory elective subject)
Identifier	1211900
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	The lecture comprises of two parts: The first part is the main part of the lecture and is focused on system security. The second part of the lecture is dedicated to privacy in applications. The first part includes: Malware, Buffer Overflows and other Memory Corruptions, Denial of Service Attacks, Access Control, Firewalls, and Intrusion Detection. The second part includes: Anonymous Communications, Electronic Payment, Biometrics, Electronic Voting, and Secure Multi-Party Computation.
Learning objective	Knowledge: On successful completion of this module, students should be able to recall the different types of malware, describe how buffer overflows work and how they can be used by an attacker, recall the different approaches for intrusion detection, recall the different types of firewalls and describe how they work, describe different approaches to protect against buffer overflows, describe the components of a biometric system and the security and privacy implications of different applications of biometric systems, describe how electronic payment methods work, state the challenges of electronic voting systems, describe different electronic voting systems and attacks against them, state the challenges of anonymous communications and explain how different anonymous communication networks work. | Skills: They should be able to identify buffer overflows and other memory corruptions in code and fix them, apply and configure firewalls, apply the Tor protocol, select and compare intrusion detection systems. | Competences: Based on the knowledge and skills acquired they should be able to identify and fix buffer overflows and other memory corruptions, assess the security and privacy of biometric systems as well as electronic payment methods and electronic voting systems. In addition, they should be able to identify weaknesses in protocols that claim to be privacy-preserving.
Requirements	None.
(recommended) Requirements	Cryptographic basics on encryption, integrity protection, signatures and authentication and key agreement. Basic knowledge on operating systems and data communication.
References	Matt Bishop: Introduction to Computer Security, Addison-Wesley. | Ross Anderson: Security Engineering - A Guide to Building Dependable Distributed Systems , Wiley.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessorin Dr.-Ing. Ulrike Meyer
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ IT-Security 2 - Computer Security (1211900)

Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise IT-Security 2 (121190002)	1st semester	no semester recommended	0	1
Exam IT-Security 2 (121190001)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture IT-Security 2	1st semester	no semester recommended	-	3

+ Knowledge Graph Analysis (KP20912)

Module titel	Knowledge Graph Analysis (Compulsory elective subject)
Identifier	KP20912
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	The module will be concentrating on the following topics: RDF Data Processing; Property Graph Databases and Querying; Statistical Relational Learning (SRL) and Associated Models; Latent Feature Models and Graph Feature Models; Tensors and Tensor Factorization Models; Neural Networks (NN) and NN for KGA; Optimization Techniques for SRL; Training and Evaluating SRL Models; Markov Logic Networks.
Learning objective	Knowledge: Learn about knowledge graphs (KG), RDFs, triples, serialization formats, SPARQL query language, concepts and components of property graph databases, Cypher as a graph query language, statistical properties of KGs, types of SRL tasks and probabilistic models, tensor representation of KGs, tensor factorization models in the context of SRL including CP and RESCAL, SGD and ALS as two approaches to train KG models, NNs and MLPs and how train them using backpropogation, SRL models investigated as NNs, latent distance models like TransE and Structural Embedding, local and global graph features, graph feature models and their usage in conjunction with other KG models, how we can train SRL in the light of closed/open world assumptions?, negative sampling, evaluation criteria, Markov logic networks (MLN) as SRL models. | Skills: Usage of serialization formats to convert a KGs to/from file, usage of query languages to query patterns of interest form KG as well as property graph databases, usage of tensor products/models numericaly, application of ALS on the RESCAL models, application of backpropogation on examples, numerical computation of translation based models, computation of graph features, evaluation of SRL models, computing MLN models and usage of logical rules in this regards, Communication skills (work and discuss together in small teams, oral or written presentation of solutions, critical examination of implementations). | Competences: Understanding KGs and the spectrum of KGA models covered in the lecture as well as the competence to select, apply the suitable learning models based on the context and analyse the model suitability and its results, Self-competences (time management, goal-oriented work, ability to analyse problems and to find practical solutions, ability to accept and formulate criticism).
Requirements	None.
(recommended) Requirements	Basic knowledge of RDF, SQL, SPARQL, Python and Machine Learning Methods.
References	M. Nickel, K. Murphy, V. Tresp, E. Gabrilovich, A Review of Relational Machine Learning for Knowledge Graphs; I. Robinson, J. Webber, and E. Eifrem. Graph Databases: New Opportunities for Connected Data, O'Reilly Media, Inc., 2nd edition, 2015; Markov Logic: An Interface Layer for Artificial Intelligence. Pedro Domingos and Daniel Lowd. 2009; RESCAL: M. Nickel, V. Tresp, and H.-P. Kriegel. \A Three-Way Model for Collective Learning on Multi-Relational Data," in Proceedings of the 28th International Conference on Machine Learning (ICML), pp. 809|816, 2011; Link prediction in social networks: Liben-Nowell and Kleinberg. The link prediction problem for social networks. Journal of the American society for information science and technology, vol. 58, no. 7, pp. 1019-1031, 2007.
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-

+ Knowledge Graph Analysis (KP20912)

Module coordinator	Universitätsprofessor Dr. rer. nat. Jens Lehmann
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Knowledge Graph Analysis (Exam) (KP2091201)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Knowledge Graph Analysis (Lecture)	no semester recommended	no semester recommended	-	4

+ Cryptography (KP20928)

Module titel	Cryptography (Compulsory elective subject)
Identifier	KP20928
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Basic private-key and public-key cryptosystems: AES, RSA, group-based. Security reductions. Key exchange, cryptographic hash functions, signatures, identification; fac-toring integers and discrete logarithms; lower bounds in structured models.
Learning objective	Knowledge: Basic cryptographic primites and their security. Relation of security notions. Mathematical tools. | Skills: Construction and analysis of cryptographic primitives based on mathematical tools and related to security notions. | Competences: Ability to assess the security of primitives and their use in applications. Critical assessment of applications.
Requirements	None.
(recommended) Requirements	None.
References	Jonathan Katz & Yehuda Lindell (2015/2008). Introduction to Modern Cryptography, CRC Press; Mike Rosulek (2017+). The Joy of Cryptography; Mihir Bellare & Shafi Goldwasser (2001); Johannes A. Buchmann (2004). Introduction to Cryptography. Birkhäuser Verlag, 2nd edition. ISBN 0-387-21156-X (hardcover), 0-387-20756-2; Douglas R. Stinson (2005). Cryptography - Theory and Practice. Discrete Mathematics and its Applications. Chapman & Hall / CRC Press, Boca Raton FL, 3rd edition. ISBN 1584885084, 600pp; Nigel Smart (2002), Cryptography: An Introduction. McGraw-Hill. ISBN 0-077-09987-7. This first edition is out of print, but a new edition is available online; Dan Boneh & Victor Shoup (2017). A Graduate Course in Applied Cryptography.
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Dr. rer. nat. Michael Nüsken
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	120
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ Cryptography (KP20928)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Cryptography (Exam) (KP2092801)	no semester recommended	no semester recommended	8	-

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Cryptography (Lecture)	no semester recommended	no semester recommended	-	6

+ Artificial Intelligence (1215694)

Module titel	Artificial Intelligence (Compulsory elective subject)
Identifier	1215694
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Agent Architecture, Heuristic Search, Games, Knowledge Representation, Baysian Networks, Machine Learning, Robotics.
Learning objective	Knowledge: Upon successful completion of this module, the student will be familiar with the basic methods underlying the design of intelligent agents, including search methods, knowledge representation using first-order logic, planning, reasoning under uncertainty, and inductive learning. | Skills: The student will be able to apply the methods taught in class to design intelligent agents him- or herself. | Competences: When developing large software systems, the student will be able to identify components and functionalities, which call for the use of Artificial Intelligence methods, and adapt and implement those methods for such purposes.
Requirements	None.
(recommended) Requirements	None.
References	Lecture Notes (Transparencies); Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (2nd Edition), Addison Wesley, 2002.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Gerhard Lakemeyer Ph. D.
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Artificial Intelligence (1215694)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Artificial Intelligence (121569402)	1st semester	no semester recommended	0	2
Exam Artificial Intelligence (121569401)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Artificial Intelligence	1st semester	no semester recommended	-	3

+ Mobile Internet Technology (1212346)

Module titel	Mobile Internet Technology (Compulsory elective subject)
Identifier	1212346
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This course addresses architectures, protocols, and algorithms for mobile Internet systems: • Physical layer: modulation, coding and signal propagation • MAC layer: challenges in wireless medium access • Wireless, data-oriented networks: 802.11 (WLAN) • Routing in Ad-hoc networks • Mobile networks: GSM, GPRS, UMTS, LTE, 5G • Mobility in the Internet: Mobile IP, HIP, TCP
Learning objective	**Knowledge**: On successful completion of this module, students should be able to: • describe the principles of wireless networks, especially 802.11 (WLAN) and telecommunication networks • state problems of the Internet protocols (IP, TCP) in mobile scenarios **Skills**: They should be able to: • use the gained knowledge to identify sources of problems in mobile scenarios and to deal with them appropriately • ;identify important common aspects in wireless network approaches **Competences**: Based on the knowledge and skills acquired they should be able to: • analyze the applicability of mobile system architectures for future mobile Internet scenarios methodically • discuss requirements to the Internet protocols in wireless systems and propose solutions how to fulfil these requirements
Requirements	None.
(recommended) Requirements	Basic knowledge in data communication is recommended
References	• Folien zur Vorlesung / Lecture Slides • J. Schiller: Mobile Communications, 2. Auflage, Addison Wesley, 2004 • W. Stallings: "Wireless Communications and Networks&;quot;. Pearson, 2nd Ed., 2014 • Weitere Spezialliteratur wird in den Vorlesungsfolien bekannt gegeben
Language	English
Grading	Written exam or oral examination (100%). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Klaus Wehrle
ECTS Credits	6

+ Mobile Internet Technology (1212346)

Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Mobile Internet Technology (121234602)	1st semester	no semester recommended	0	1
Exam Mobile Internet Technology (121234601)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Mobile Internet Technology	1st semester	no semester recommended	-	3

+ Mobile Radio Networks 1 (6010380)

Module titel	Mobile Radio Networks 1 (Compulsory elective subject)
Identifier	6010380
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Summer semester 2011
Valid until	-
Module level	Master
Content	# radio wave propagation models # concepts of cellular systems # handover mechanisms # system architecture of modern cellular systems # logical and physical channels # system security in voice networks
Learning objective	Specific skills: # Students will gain knowledge of the possibilities and limits of mobile radio communications and explore them based on current models # Students will learn the basic terminology for relevant topics in the area of telecommunications # Students will understand the design space of cellular networks, especially with respect to radio propagation and systems engineering General skills: # Students will broaden their knowledge of multi-parametric systems design # Students will extend their knowledge of mathematical modelling through abstraction # Students will be able to gauge the basic feasibility of different communication technologies and network designs for specific application areas, e.g. broadband multimedia traffic vs. machine-to-machine low rate traffic
Requirements	-
(recommended) Requirements	Basic knowledge in the area of communication networks and electromagnetic wave propagation
References	# Theodore S. Rappaport, Wireless Communications: Principles and Practice (2nd Edition), Prentice Hall # Y.B. Lin and I. Chlamtac, Wireless and Mobile Network Architectures, Wiley # R. Steele, Mobile Radio Communications, Wiley # J. Eberspächer et al., GSM Switching, Services and Protocols (2nd Edition), Wiley.
Language	English
Grading	written examination
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Marina Petrova
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	90
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

+ Mobile Radio Networks 1 (6010380)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Mobile Radio Networks 1 (601038001)	1st semester	no semester recommended	4	3

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Mobile Radio Networks 1	1st semester	no semester recommended	-	3

+ Model-based Systems Engineering (1222882)

Module titel	Model-based Systems Engineering (Compulsory elective subject)
Identifier	1222882
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2020
Valid until	-
Module level	Master
Content	After a thorough and detailed introduction of SysML and UML, the possibilities of using models in system development processes are discussed. These include simulation, code and test case generation, analysis, modeling and evolution of systems by refactoring of models.
Learning objective	Knowledge: • SysML, UML • MontiArc • Architecture and behavior models • Statecharts, finite automata • Object diagrams and class diagrams • Geometrical models and their connection to software controlling models • Use of models in the software and systems engineering process • Simulation, code, and test generation • Analysis of models • Evolution of models and systems Skills: • Application of models in the development process • Ability to read and write own models in appropriate languages Competences: • Understanding of the use of models • Application of models in software and systems engineering • Knowledge and practice of SysML and UML • Designing systems with a strong software impact by using model-based development techniques
Requirements	-
(recommended) Requirements	Introduction to software engineering or comparable courses.
References	[Rum17] B. Rumpe: Agile Modeling with UML: Code Generation, Testing, Refactoring. Springer International, May 2017. [CFJ+16] B. Combemale, R. France, J. Jézéquel, B. Rumpe, J. Steel, D. Vojtisek: Engineering Modeling Languages: Turning Domain Knowledge into Tools. Chapman &; Hall/CRC Innovations in Software Engineering and Software Development Series, November 2016.
Language	English
Grading	Written exam or oral examination (100%). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	-
ECTS Credits	6

+ Model-based Systems Engineering (1222882)

Contact time (WSH)	5
Examination duration (min)	-
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Model-based Systems Engineering (122288201)	no semester recommended	no semester recommended	6	0
Exercise Model-based Systems Engineering (122288202)	no semester recommended	no semester recommended	0	3

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Model-based Systems Engineering	no semester recommended	no semester recommended	-	2

+ Model-Based Software Engineering (1215686)

Module titel	Model-Based Software Engineering (Compulsory elective subject)
Identifier	1215686
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	After an introduction of UML, the possibilities of using models in the software development process are discussed. These include simulation, code and test case generation, analysis, modeling and evolution of systems by refactoring of models. Topics: UML, Use of models in the software engineering process, Simulation, code and test generation, Analysis of models, Evolution of models by refactoring.
Learning objective	Understanding of the use of models, Application of models in software engineering, Knowledge and practicing of UML
Requirements	None.
(recommended) Requirements	Knowledge of “Software Engineering”.
References	B. Rumpe: Modellierung mit UML : Sprache, Konzepte und Methodik, Springer, 2016, B. Rumpe : Agile Modellierung mit UML : Codegenerierung, Testfälle, Refactoring. Springer, 2017
Language	German/English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Bernhard Rumpe
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Model-Based Software Engineering (1215686)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Model-Based Software Engineering (121568602)	1st semester	no semester recommended	0	3
Exam Model-Based Software Engineering (121568601)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Model-Based Software Engineering	1st semester	no semester recommended	-	2

+ Object Oriented Software Construction (1212354)

Module titel	Object Oriented Software Construction (Compulsory elective subject)
Identifier	1212354
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This module introduces central methods, techniques and processes of systematic software construction based on object-oriented concepts. The lecture covers the following topics: Foundations of object orientation | Software reuse | Design by Contract | Inheritance, polymorphism and generics | Software design principles | Domain modelling, domain driven design | Component technology - Advanced patterns and frameworks | Smells and Refactoring
Learning objective	Study goals: After completing the module the students have the following knowledge and competencies: they know how to apply important object oriented modeling concepts| they are able to perform use case based and domain driven design | they know the concepts of framework based development | they know important design patterns and are able to apply patterns in architectural design | they know how to improve code and architecture based on smells and refactoring | they know the architecture of Java based component models. Benefits for future professional life / soft skills: All competencies are trained in the exercises, where small teams of students have to create typical analysis, design and implementation artefacts. They have to present and discuss their solutions and ideas in front of the class. As professional knowledge on software construction is provided, students gain personal and professional competencies that enable to work as software architects.
Requirements	None.
(recommended) Requirements	Knowledge of “Software Engineering”.
References	Meyer, B. (1997) : Object Oriented Software Construction, 2nd edition, Prentice Meyer, B. (1997): Object Oriented Software Construction, 2nd edition, Prentice Hall | Züllighoven, H. (2005): Object-Oriented Construction Handbook – Developing Application-Oriented Software with the Tools and Materials Approach. dpunkt.verlag, Heidelberg | Erich Gamma, Richard Helm, Ralph Johnson, John Vlissides (1995): Design Patterns, Addison-Wesley | Fowler Martin (1999): Refactoring - Improving the design of existing code, Addison Wesley.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Horst Lichter
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Object Oriented Software Construction (1212354)

Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Object Oriented Software Construction (121235402)	1st semester	no semester recommended	0	2
Exam Object Oriented Software Construction (121235401)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Object Oriented Software Construction	1st semester	no semester recommended	-	3

+ Online Algorithms (1212645)

Module titel	Online Algorithms (Compulsory elective subject)
Identifier	1212645
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	A selection of important online problems, such as: Paging, k-Server, List Access, Data Management, Rucksack, Job Scheduling, graph problems, Bit Guessing. An introduction to randomization and advice complexity.
Learning objective	Knowledge: At the end of this course, the students should be able to describe foundational problems arising in online algorithm and explain algorithmic solutions for these problems.| Skills: The students should be able to apply general algorithmic design principles and to use techniques to solve problems arising for online problems. | Competences: The students should be able to model online problems in a formal way and to develop algorithmic solutions for these problems.
Requirements	None.
(recommended) Requirements	Basic knowledge on algorithms, discrete structures and statistics.
References	Dennis Komm, An introduction to online computation: determinism, randomization, advice, Springer 2015 |A. Borodin, R. El-Yaniv: Online Computation and Competitive Analysis, Cambridge University Press 2005
Language	English
Grading	This module can alternatively be completed as 6 ECTS (V3+Ü2) or 8 ECTS (V4+Ü2). The module examination is a written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Gerhard Woeginger & Dr. rer. nat. Walter Unger
ECTS Credits	6
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	90
Self-study hours (h)	90

+ Online Algorithms (1212645)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Online Algorithms (121264503)	1st semester	no semester recommended	0	2
Extended Exam Online Algorithms (121264501)	1st semester	no semester recommended	8	0
Exam Online Algorithms (121264502)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Online Algorithms	1st semester	no semester recommended	-	3
Extended Lecture Online Algorithms	1st semester	no semester recommended	-	1

+ Principles and Architectures of Cognitive Radios (6010406)

Module titel	Principles and Architectures of Cognitive Radios (Compulsory elective subject)
Identifier	6010406
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2011
Valid until	-
Module level	Master
Content	# Software defined radios # Dynamic spectrum access # Radio intelligence # Optimization of communication networks using machine learning # Modeling of interactions between cognitive radios
Learning objective	Specific skills: # Students know the structure of software-based radio systems and the relevant signal processing tasks # Students comprehend the design of cognitive medium access control and networks protocols and the specific parameters that are set through regulation and user requirements # Students can name principles of well-known cognitive medium access control and network protocols and put in the context of system design General skills: # Students broaden their knowledge on multi-parametric systems design # Students extend their knowledge on mathematical modeling of radio systems # Students learn to use scientific papers and analyze them critically # Students improve their presentation skills in the field in English
Requirements	-
(recommended) Requirements	Basic knowledge in the design of communication networks, signal processing, coding and modulation of information streams
References	# Alexander Wyglinski and Maziar Nekovee and Thomas Hou, Cognitive Radio Communications and Networks: Principles and Practice, Academic Press # Modern scientific Reading Liste in the area of cognitive radio networks, e.g. from relevant IEEE and ACM journals and conferences.
Language	English
Grading	oral examination (30min) or written examination (90min)
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. Petri Mähönen
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	30 or 90
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

+ Principles and Architectures of Cognitive Radios (6010406)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Principles and Architectures of Cognitive Radios (601040601)	2nd semester	no semester recommended	4	3

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise Principles and Architectures of Cognitive Radios	2nd semester	no semester recommended	-	3

+ Research Focus Class on Communication Systems (1212347)

Module titel	Research Focus Class on Communication Systems (Compulsory elective subject)
Identifier	1212347
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This research-oriented course addresses students with an interest in current Internet technology research and development. A selected topic from the following areas of communication systems will be discussed: • Network architectures • Cyber-physical systems • Security and privacy • Systems analysis. The course starts with an overview on the state of the art in the selected subject area. Basing on this introductory part, the students identify specific research topics (guided by the teaching assistants) for scientific examination of certain aspects. Each student presents a topic with focus on research questions. In the second part of the course the students work on their topic practically (prototypical implementation, simulations, analysis, ...). The concrete outline might vary from semester to semester, depending on the topical area.
Learning objective	**Knowledge:** • Detailed knowledge of current research in communication and distributed systems **Skills:** • Knowledge of scientific methods for obtaining results, theoretically as well as practically **Competences:** • Deepened understanding of a selected current topic • Ability to independently familiarize oneself with a research topic
Requirements	None.
(recommended) Requirements	Knowledge of lecture "Advanced Internet Technology" ;are helpful.
References	Current literature on selected topics; will be announced in the course.
Language	German
Grading	The module examination consists of the following partial examinations: Oral examination (20 %); Presentation (40 %); Practical Training/Lab (40 %). Students must pass written homework to be admitted to the partial qualifications.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Klaus Wehrle
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Research Focus Class on Communication Systems (1212347)

Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Research Focus Class on Communication Systems (121234704)	1st semester	no semester recommended	0	2
Practical Course Research Focus Class on Communication Systems (121234702)	1st semester	no semester recommended	0	0
Presentation Research Focus Class on Communication Systems (121234703)	1st semester	no semester recommended	0	0
Exam Research Focus Class on Communication Systems (121234701)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Research Focus Class on Communication Systems	1st semester	no semester recommended	-	3

+ Security in Mobile Communication (1212681)

Module titel	Security in Mobile Communication (Compulsory elective subject)
Identifier	1212681
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Security architectures and attacks against already standardized wireless communication systems. In particular: mobile networks such as GSM, UMTS, LTE, wireless local area networks (WLAN), personal area networks such as Bluetooth and Sensor Networks, wide area networks such as WiMax, classical cordless telephony networks such as DECT, as well as RFID systems. In addition, upcomming wireless networks will be covered.
Learning objective	Knowledge: On successful completion of this module, students should be able to describe the security features and mechanisms of the wireless communication technologies GSM, UMTS, LTE, WLAN, WiMax, Bluetooth, RFID, ZigBee, and DECT. They should be able to recall common mechanisms such as the extensible authentication protocol EAP and different versions of Mobile IP wich are used in several of the above technologies. They should be able to describe known attacks and countermeasures against these technologies. | Skills: They should be able to compare different wireless technologies with respect to the offered security and privacy features, and assess the severity of known attacks against wireless systems. | Competences: based on the knowledge and skills acquired they should be able to assess the severity of upcoming attacks against wireless systems, identify the security requirements for upcoming wireless systems, design security mechanisms for upcoming wireless systems, identify potential weaknesses in technologies not covered in the lecture and propose appropriate countermeasures.
Requirements	None.
(recommended) Requirements	Cryptographic basics on encryption, integrity protection, signatures and authentication and key agreement. Basic knowledge on mobile technologies is helpful but not required.
References	The course covers the topics in a depth that is not provided by any text book. References to the relevant standards documents and research papers are provided for each chapter.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessorin Dr.-Ing. Ulrike Meyer
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60

+ Security in Mobile Communication (1212681)

Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Security in Mobile Communication (121268102)	1st semester	no semester recommended	0	1
Exam Security in Mobile Communication (121268101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Security in Mobile Communication	1st semester	no semester recommended	-	3

+ Social Computing (1212678)

Module titel	Social Computing (Compulsory elective subject)
Identifier	1212678
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	Social Computing is concerned with the intersection of social behavior and computational systems. Thus, social software illustrate ideas from social computing, but also other kinds of software applications where people interact socially. The content is as follows. The Web as Social Computing Platform: Web Servers, Web (Micro)-Services, Internet of Things etc., Security, Authentication &; Authorization, Content Management Systems, Social Networking Sites, Social Software and Web 2.0, Wikis, Blogs, Instant Messaging, Social Bookmarking, Social Bots, Community Information Systems;The Social Computing Development Process: Large-Scale Social Requirements &; Software Engineering, Human Aspects, DevOpsUse, Collaborative Modeling, OSS Development, Quality Management, Issue Tracking, Monitoring, Multi-Agent Platforms, Real-Time Social Computing, Operational Transformation (OT), Commutative Replicated Data Types (CRDT); Computational Social Science: Data Mining and Machine Learning, Visualization of Networks, Recommendations, Collaborative Filtering, Reputation&; Trust, (Overlapping) Community Detection, Signed Social Networks, Social Media Content Measures, Expert Identification, Robustness; Applications Areas of Social Computing: Matchmaking, Advertisement, Online Dating, Online Gaming, Crowdsourcing, Collective Intelligence, Open Innovation, Dark Social Media; Advanced Social Computing Topics: Mobile Social Computing, Gamification &; Serious Games, Social Augmented &; Virtual Reality, Science 2.0, Social Media for Scientists, Digital Humanities.
Learning objective	Knowledge: On successful completion of this module, students should be able to differentiate the terms and generations of the social computing platforms, processes, algorithms, and applications, recall the fundamental issues of the social computing sub discipline of computer science, describe the fundamental processes, platforms and strategies for near-real time social computing such as operational transformations and commutative replicated data types, describe leading base algorithms and strategies (Recommending, matchmaking, crowdsourcing) for social computing platforms, recall theories for the analysis and visualization of social networks. Skills: They should be able to analyze and apply different algorithms for social computing, creatively use advanced development methods on realistic development and consulting projects in social computing, interact socially with other developers and with end users from different cultures in analyzing requirements and problems in the Web, analyze the dynamics of the Web and its services and platforms. Competences: Based on the knowledge and skills acquired, they should be able to critically analyze and discuss proposed social computing services and changing regulations in the Internet sector, cooperate in local and distributed community teams to develop improved social computing services.
Requirements	None.
(recommended) Requirements	Basic knowledge in web engineering, stochastics, linear algebra and social software.
References	References are given in the slides.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-

+ Social Computing (1212678)

Module coordinator	Dr. rer. nat. Ralf Klamma
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Social Computing (121267801)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture + Exercise Social Computing	1st semester	no semester recommended	-	3

+ Software Project Management (1212355)

Module titel	Software Project Management (Compulsory elective subject)
Identifier	1212355
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	Contents: The following areas are covered: Project management foundations and basic processes | Software development process models | Agile development models | Project planning techniques | Traditional and agile cost estimation techniques | Project scheduling techniques | Project controlling and monitoring | Risk management | Stakeholder management and decision analysis techniques
Learning objective	Study goals: General: The module introduces central aspects and techniques of modern project management. Hence, students will be familiar with goals, major activities, and techniques of software project management. Furthermore, they will have a detailed understanding on how project management and software development activities relate and collaborate. Altogether, this knowledge will be put together in terms of modern software development processes. Skills: Students will be able to plan, estimate, control and assess project risks. All these skills are trained in the exercises, where small teams of students have to create important project management artefacts. They have to present and discuss their solutions and ideas in front of the class. Benefits for future professional life / soft skills: Knowledge on project team leadership is provided. Together with competencies e.g. in stakeholder management and decision analysis techniques, students gain personal and professional competencies that enable to take over leadership responsibilities in industry.
Requirements	None.
(recommended) Requirements	Knowledge of “Software Engineering”.
References	H. Kerzner (2002): Project Management - A Systems Approach to Planning, Scheduling and Controlling, Wiley | IEEE Std 1490 (2003): Adoption of PMI Standard A Guide to the Project Management Body of Knowledge | Wysocki, R. (2007): Effective Project Management, Wiley Publishing Inc.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Horst Lichter
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45

+ Software Project Management (1212355)

Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Software Project Management (121235501)	1st semester	no semester recommended	4	0
Exercise Software Project Management (121235502)	1st semester	no semester recommended	0	1

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Software Project Management	1st semester	no semester recommended	-	2

+ Advanced Machine Learning (1211912)

Module titel	Advanced Machine Learning (Compulsory elective subject)
Identifier	1211912
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Regression techniques, Probabilistic Graphical Models, Exact Inference, Approximate Inference, Deep Generative Models, Deep Reinforcement Learning
Learning objective	Knowledge: On successful completion of this module, students should be able to recall and explain the theoretical foundations and concepts underlying advanced Machine Learning techniques, in particular * Linear regression * Regularization * Gaussian Processes * Bayesian Estimation * Probabilistic Graphical Models: Bayesian Networks, Markov Random Fields * Exact Inference: Belief Propagation, Junction Graphs * Approximate inference: Sampling techniques, MCMC, Variational Inference * Bayesian Non-Parametric Methods (Dirichlet Processes) * Deep Generative Models: Variational Auto-Encoders Skills: They should be able to derive, explain, and apply the following practical machine learning methods and algorithms: * Linear regression: Least-squares regression, Ridge regression, Kernel Ridge regression * Maximum Likelihood estimation, Maximum-A-Posteriori estimation, Bayesian estimation * Gaussian Process Regression * Sum-Product Belief Propagation, Max-Sum Belief Propagation * Rejection Sampling, Importance Sampling, Markov Chain Monte Carlo, Gibbs Sampling * Variational Inference * Dirichlet Processes: Stick-breaking construction Competences: Based on the knowledge and skills acquired, they should be able to * discuss the advantages and disadvantages of the covered machine learning techniques * find practical solutions to complex real-world machine learning problems * work on practical problems in a tea
Requirements	None.
(recommended) Requirements	Basic knowledge in Linear Algebra, Probability Theory, and Statistics is recommended. Successful completion of the lecture Machine Learning is recommended.
References	C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006. | I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, 2016. | R.S. Sutton, A.G. Barto, Reinforcement Learning: An Introduction, 2nd Edition, MIT Press, 2018.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. sc. techn. Bastian Leibe
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Advanced Machine Learning (1211912)

Contact hours (h)	60
Self-study hours (h)	120

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Machine Learning (121191202)	1st semester	no semester recommended	0	1
Exam Advanced Machine Learning (121191201)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Machine Learning	1st semester	no semester recommended	-	3

+ Advanced Methods in Automatic Speech Recognition (1211904)

Module titel	Advanced Methods in Automatic Speech Recognition (Compulsory elective subject)
Identifier	1211904
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Summary of large vocabulary speech recognition using a linear lexicon. | Search using lexical pronunciation prefix trees. | Word graph method using word pair approximation. | Time-conditioned search. | Across-word modeling. | Confidence measures and system combination. | Discriminative training. | Speaker adaptation and normalization. | Current issues.
Learning objective	Knowledge: On successful completion of this module, students should be able to describe the components and formalisms of a state-of-the-art automatic speech recognition system; | state the optimization problems underlying training, adaptation, and recognition using state-of-the-art automatic speech recognition components and underlying models. Skills: They should be able to: apply state-of-the-art automatic speech recognition components | solve the optimization problems underlying training, adaptation, and recognition using state-of-the-art automatic speech recognition components and underlying models | should have acquired soft skills like developing and testing ASR software in a cooperative environment. Competences: Based on the knowledge and skills acquired they should have an overview of the state-of-the-art in automatic speech recognition | be able to analyze the effect of the components of state-of-the-art automatic speech recognition systems | be able to interpret the implementation of a speech recognition system | be in a position to realize specific problems of automatic speech recognition.
Requirements	None.
(recommended) Requirements	Knowledge in Automatic Speech Recognition.
References	F. Jelinek: Statistical Methods for Speech Recognition, MIT Press, Cambridge 1997. | D. Jurafsky, J.H. Martin: Speech and Language Processing, Prentice Hall, Englewood Cliffs, NJ, 2000. | R. De Mori: Spoken Dialogues with Computers, Academic Press, London, 1998. | Publications on automatic speech recognition.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Hermann Ney
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Advanced Methods in Automatic Speech Recognition (1211904)

Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Methods in Automatic Speech Recognition (121190402)	1st semester	no semester recommended	0	2
Exam Advanced Methods in Automatic Speech Recognition (121190401)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Methods in Automatic Speech Recognition	1st semester	no semester recommended	-	3

+ Advanced Statistical Classification (1212684)

Module titel	Advanced Statistical Classification (Compulsory elective subject)
Identifier	1212684
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Introduction/Motivation | Summary of Introduction to Pattern Recognition | Discriminants and Neural Networks | Training criteria | Log-linear modeling | Support Vector Machines | Classification and regression trees. | Boosting | Model Selection
Learning objective	Knowledge: On successful completion of this module, students should be able to: describe the various applications of advanced state-of-the-art methods of statistical classification. | describe the fundamental properties and methods of statistical classification. | describe the advanced methods for training a statistical classification system. | describe the trade-off between system complexity and performance in advanced statistical classification system. Skills: They should be able to: implement advanced methods of statistical classification. | to train the parameters of a statistical classification system using advanced training methods. | apply and implement advanced methods of statistical classification | measure and analyze the performance of a statistical classification system in complex real-life applications. Competences: Based on the knowledge and skills acquired they should: have an overview of advanced methods in statistical classification. | be able to apply advanced methods of statistical classification. | be in a position to analyze specific problems in | a real-life application of a statistical classification system.
Requirements	None.
(recommended) Requirements	None.
References	R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification. 2nd ed., J. Wiley, New York, NY, 2001. | K. Fukunaga: Introduction to Statistical Pattern Recognition. Academic Press, New York, NY, 1990.
Language	German/English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Hermann Ney
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Advanced Statistical Classification (1212684)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Pattern Recognition Methods (121268403)	1st semester	no semester recommended	0	2
Exam Advanced Pattern Recognition Methods (121268402)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Pattern Recognition Methods	1st semester	no semester recommended	-	3

+ Automatic Speech Recognition (1215750)

Module titel	Automatic Speech Recognition (Compulsory elective subject)
Identifier	1215750
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Introduction/motivation. | Digital signal processing. | Spectral Analysis. | Time alignment and isolated word recognition. | Statistical interpretation and models. | Connected Word Recognition. | Large Vocabulary Speech Recognition.
Learning objective	Knowledge: On successful completion of this module, students should be able to: describe the components and formalisms of a state-of-the-art automatic speech recognition system; | state the optimization problems underlying training, adaptation, and recognition using state-of-the-art automatic speech recognition components and underlying models. Skills: They should be able to:apply state-of-the-art automatic speech recognition components; | solve the optimization problems underlying training, adaptation, and recognition using state-of-the-art automatic speech recognition components and underlying models; | and should have acquired soft skills like developing and testing ASR software in a cooperative environment. Competences: Based on the knowledge and skills acquired they should:have an overview of the state-of-the-art in automatic speech recognition; | be able to analyze the effect of the components of state-of-the-art automatic speech recognition systems; | be able to interpret the implementation of a speech recognition system; | be in a position to realize specific problems of automatic speech recognition.
Requirements	None.
(recommended) Requirements	None.
References	Emphasis on signal processing and small-vocabulary recognition: L. Rabiner, B. H. Juang: Fundamentals of Speech Recognition. Prentice Hall, Englewood Cliffs, NJ, 1993. | Emphasis on large vocabulary and language modelling: F. Jelinek: Statistical Methods for Speech Recognition. MIT Press, Cambridge, 1997. | Introduction to both speech and language: D. Jurafsky, J. H. Martin: Speech and Language Processing. Prentice Hall, Englewood Cliffs, NJ, 2000. | Advanced topics: R. De Mori: Spoken Dialogues with Computers. Academic Press, London, 199.
Language	German/English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Hermann Ney
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240

+ Automatic Speech Recognition (1215750)

Contact hours (h)	90
Self-study hours (h)	150

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Automatic Speech Recognition (121575002)	1st semester	no semester recommended	0	2
Exam Automatic Speech Recognition (121575001)	1st semester	no semester recommended	8	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Automatic Speech Recognition	1st semester	no semester recommended	-	4

+ Image Processing (KP20915)

Module titel	Image Processing (Compulsory elective subject)
Identifier	KP20915
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Technical foundations of digital imaging, mathematical representations of digital images,properties of vector spaces and coordinate systems, affine and linear transformations, homogeneous coordinates, polar coordinates, complex exponentials, Fourier transforms, low-, band- and high-pass filters, convolutions, Gaussian and linear filters and how to implement them efficiently, non-linear filters, median filters, morphological operations, interpolation techniques, image warping and artistic image effects, bi-linear and perspective mesh warping, image morphing, color spaces, color transformations.
Learning objective	Acquisition of knowledge about methods of image and signal processing; acquisition of knowledge about the practical implementation of corresponding mathematical methods and algorithms.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Bauckhage
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ Image Processing (KP20915)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Image Processing (Exam) (KP2091501)	no semester recommended	no semester recommended	8	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Image Processing (Lecture)	no semester recommended	no semester recommended	-	6

+ Computer Vision (1215724)

Module titel	Computer Vision (Compulsory elective subject)
Identifier	1215724
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Image Processing Basics, Image Segmentation, Object Recognition, Object Categorization, 3D Reconstruction, Application of current Machine Learning methods to the above-mentioned problems.
Learning objective	Knowledge: On successful completion of this module, lecture participants should be able to recall and explain the theoretical foundations underlying Computer Vision techniques in the areas mentioned under “Content”. | Skills: Lecture participants can derive and explain methods and techniques that enable a machine to analyze the content of images and videos and to derive an understanding of the image content. They know the current research trends and developments. This enables them to select the basic Computer Vision techniques necessary for those capabilities. | Competences: Lecture participants are able to apply the covered methods to real problems on their own. They are able to implement the covered algorithms themselves in a language of their choice.
Requirements	None.
(recommended) Requirements	Basic knowledge in linear algebra, probability theory and statistics is recommended.
References	R. Szeliski, Computer Vision - Algorithms and Applications, Springer, 2010 | K. Grauman, B. Leibe, Visual Object Recognition, Morgan & Kaufman publishers, 2011 | I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, 2016 | R. Hartley, A. Zisserman. Multiple View Geometry in Computer Vision, 2nd Edition, Cambridge University Press, 2004.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. sc. techn. Bastian Leibe
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Computer Vision (1215724)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Computer Vision (121572402)	1st semester	no semester recommended	0	1
Exam Computer Vision (121572401)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Computer Vision	1st semester	no semester recommended	-	3

+ Computer Vision 2 (1211921)

Module titel	Computer Vision 2 (Compulsory elective subject)
Identifier	1211921
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Single-Object Tracking, Recursive Bayesian Filtering, Multi-Object Tracking, Visual Odometry, SLAM
Learning objective	Knowledge: On successful completion of this module, lecture participants should be able to recall and explain the theoretical foundations underlying Computer Vision techniques in the areas mentioned under “Content”. | Skills: Lecture participants can derive and explain methods and techniques that enable a machine to analyze the content of images and videos and to derive an understanding of the image content. They know the current research trends and developments. This enables them to select the basic Computer Vision techniques necessary for those capabilities. | Competences: Lecture participants are able to apply the covered methods to real problems on their own. They are able to implement the covered algorithms themselves in a language of their choice.
Requirements	None.
(recommended) Requirements	Basic knowledge of linear algebra, probability theory, and statistics are recommended. Successful completion of the lecture Computer Vision is recommended.
References	R. Szeliski, Computer Vision - Algorithms and Applications, Springer, 2010. | S. Thrun, W. Burgard, D. Fox, Probabilistic Robotics, MIT Press, 2006. | Multiple View Geometry, R. Hartley, A. Zisserman, 2nd edition, Cambridge University Press, 2003 | An Invitation to 3D Vision, Y. Ma, S. Soatto, J. Kosecka, S. Sastry, Springer, 2003
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. sc. techn. Bastian Leibe
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Computer Vision 2 (1211921)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Computer Vision 2 (121192102)	1st semester	no semester recommended	0	1
Exam Computer Vision 2 (121192101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Computer Vision 2	1st semester	no semester recommended	-	3

+ Deep Learning for Visual Recognition (KP21638)

Module titel	Deep Learning for Visual Recognition (Compulsory elective subject)
Identifier	KP21638
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Neural networks are making a comeback! Deep learning has taken over the machine learning community by storm, with success both in research and commercially. Deep learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotics, etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional and recurrent neural networks as well as their use in applications for visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Scheduled topics include: Introduction, Machine Learning Basics, Introduction to Neural Networks, Optimization in Neural Networks, Regularization in Neural Networks, Convolutional Neural Networks, Sequential Models, Autoencoders and Decoders, Deep Generative Models and Applications / Project Presentations.
Learning objective	Knowledge: Understanding of basic neural network architectures (traditional neural networks, convolutional neural networks, recurrent neural networks, autoencoders, generative adversarial networks) | Skills: Implementation of basic neural network architectures (traditional neural networks, convolutional neural networks, recurrent neural networks, autoencoders, generative adversarial networks) | Competences: Understanding and implementation of basic neural network architectures (traditional neural networks, convolutional neural networks, recurrent neural networks, autoencoders, generative adversarial networks)
Requirements	None.
(recommended) Requirements	Students should already be comfortable with concepts in probability theory and optimization and are recommended to have taken at least one course in machine learning or computer vision. Exercises will be a mix of theory and practical (Python).
References	Ian Goodfellow and Yoshua Bengio and Aaron Courville, Deep Learning, MIT Press (html version accessible at http://www.deeplearningbook.org/)
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Dr. rer. nat. Michael Weinmann
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Deep Learning for Visual Recognition (KP21638)

Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Deep Learning for Visual Recognition (Exam) (KP2163801)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Deep Learning for Visual Recognition	no semester recommended	no semester recommended	-	4

+ Design Thinking (KP21491)

Module titel	Design Thinking (Compulsory elective subject)
Identifier	KP21491
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	This is an introductory course to Design Thinking. We will get to know the basic concepts of Design Thinking as well as selected methodologies for each phase. We will have the opportunity to try out our methods hands-on, using concrete examples.
Learning objective	Students will acquire or strengthen a set of highly relevant qualifications. Knowledge: Conduct applied research, Deeply understand at least one field or problem of everyday life, Learn and apply innovation and creativity techniques, Learn and apply methodological knowledge, Learn to prototype at different levels and methods. | Skills: Work in a team and take over responsibility, Learn to work with people, Learn to present and support your ideas in front of a critical audience. | Competences: Gain practical experience with software engineering tools, Work with state-of-the-art technology, Apply methodological knowledge.
Requirements	None.
(recommended) Requirements	Knowledge of "Designing Interactive Systems I" is recommended.
References	To be announced during class.
Language	English
Grading	The module examination consists of the following partial qualifications: Written homework (20 %); project work (30 %); Written exam or oral examination (50 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Matthias Jarke & Sarah Suleri
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Design Thinking (KP21491)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Design Thinking (Exam) (KP2149101)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Design Thinking (Lecture)	no semester recommended	no semester recommended	-	-

RWTH AACHEN UNIVERSITY

+ Designing Interactive Systems II (1215699)

Module titel	Designing Interactive Systems II (Compulsory elective subject)
Identifier	1215699
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This module builds on the foundations of Designing Interactive Systems I, and provides an understanding of how interactive multimedia systems are built from a computer science point of view. It covers the principles of event-based operating systems, window system architectures, input and output device technology for multiple modalities, as well as User Interface Management Systems and UI development toolkits and their relative merits. In the labs, students will develop a minimalistic window system themselves, but also learn to work with various real-life development environments, including window systems such as Java Swing and multimedia development environments, to develop user interfaces.
Learning objective	Knowledge: After this class, students will know how the technology behind interactive systems works. Students should be able to describe the architecture of classic and modern window systems. | Skills: They can analyze, design, and implement graphical and other user interfaces for existing and emerging technologies, both for the desktop and beyond, and including interfaces for multimedia contents. Group-based, project-centered assignments and lab activities convey hands-on experience building user interfaces and foster project management and teamwork skills. | Competences: 50–90% of development effort for today's applications go into the user interface (UI). A sound understanding of the techniques, advantages, and pitfalls of the various user interface development approaches used in industry will help students to make informed decisions when implementing or managing UI design projects in industry, and will give them a crucial head start when asked to create new UI architectures for the rapidly growing markets of next-generation devices and applications.
Requirements	None.
(recommended) Requirements	None.
References	Own script, plus collection of papers about seminal system designs.
Language	English
Grading	The module examination consists of the following partial qualifications: Written homework and project work (40 %); "midterm" written exam or oral examination (25 %); written exam or oral examination (35 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Oliver Borchers
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Designing Interactive Systems II (1215699)

Contact hours (h)	75
Self-study hours (h)	105

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Execise Designing Interactive Systems II (121569902)	1st semester	no semester recommended	0	2
Exam Designing Interactive Systems II (121569901)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Designing Interactive Systems II	1st semester	no semester recommended	-	3

+ DSP Design Methodologies and Tools (6010452)

Module titel	DSP Design Methodologies and Tools (Compulsory elective subject)
Identifier	6010452
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2009
Valid until	-
Module level	Master
Content	# Introduction: Definition of embedded systems; design challenges; design methodologies # System design: System design methodologies; requirements and specification # Instruction sets: Basic classification of computer architecture; assembly language; examples of software assembly instruction-set # Microprocessors: Various I/O mechanism; supervisor mode, exceptions, traps; co-processor # Designing with microprocessors: Architectures and components (software, hardware); debugging; manufacturing testing # Program design & analysis: Design patterns; representation of programs; assembling, linking # VLSI implementation: Importance of VLSI; Moore's Law; VLSI design process # RTL components: Shifters; adders; multipliers # Architecture and chip design: Basics of register-transfer design; data path, controller; ASM chart; VHDL, Verilog overview # CAD systems and algorithms: CAD systems; placement and routing; layout analysis
Learning objective	The students will acquire a basic understanding of the design of embedded signal processing systems. At the end of the module students are able # to construct system-level models using abstract specification languages such as StateCharts. # to develop optimized software for Digital Signal Processors in C and assembly language and # to implement simple combinational and sequential digital hardware circuits using the VHDL hardware description language.
Requirements	-
(recommended) Requirements	Basic C or assembly programming capabilities
References	# Wayne Wolf: Computers as Components - Principles of Embedded Computing Design, Morgan Kaufmann Publishers, 2001, ISBN 1-55860-541-X # Wayne Wolf: Modern VLSI Design - System-on-Chip Design, 3rd Edition, Prentice Hall, 2002, ISBN 0-13-061970-1
Language	English
Grading	Written examination
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Rainer Leupers
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	90
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

+ DSP Design Methodologies and Tools (6010452)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam DSP Design Methodologies and Tools (601045201)	2nd semester	no semester recommended	4	3

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture and Exercise DSP Design Methodologies and Tools	2nd semester	no semester recommended	-	3

+ Advanced Topics of Virtual Reality (1212688)

Module titel	Advanced Topics of Virtual Reality (Compulsory elective subject)
Identifier	1212688
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	The lecture is about specific topics of Virtual Reality. In this course, we are going to introduce, discuss and evaluate techniques and methods of VR based on current research work and application-oriented projects. In particular, the lecture comprises the following aspects: Methods of interaction and navigation in 3D space, multimodal interaction including haptic and audio interfaces, immersive visualization as a combination of scientific visualization and VR, virtual humans, formal user studies.
Learning objective	Knowledge: After a successful completion of this module, students should have gained knowledge about the following topics: Design, implementation and evaluation of 3D User Interfaces, Current developments in interface technology for Virtual Reality, Integration of haptic and acoustic stimuli in virtual environments, Methods of Virtual Reality in Simulation and Data Science, Creation and simulation of and interaction with virtual humans in virtual environments, Systematic evaluation of the quality of user interfaces via formal user studies | Skills: Students should be able to: design, implement and evaluate complex, multimodal interactions for immersive VR systems, independently understand, re-implement and further develop current research work on Virtual Reality | Competences: based on the knowledge and the skills, students should be able to: develop VR techniques and methods to solve technical and scientific problems, work independently and scientifically in the discipline of Virtual Reality
Requirements	None.
(recommended) Requirements	Basic knowledge of Virtual Reality and Linear Algebra.
References	D. Bowman et al. 3D User Interfaces. Addison-Wesley | K. M. Stanney. Handbook of Virtual Environments. Erlbaum | M.Slater et al. Computer Graphics & Virtual Environments. Addison-Wesley | G. Burdea, P. Coiffet. Virtual Reality Technology. John Wiley & Sons | K.-F. Kraiss (Ed.). Advanced Man Machine Interfaces. Springer | R.S. Kalawski. The Science of Virtual Reality and Virtual Environments. Addison Wesley
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Torsten Wolfgang Kuhlen
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Advanced Topics of Virtual Reality (1212688)

Contact hours (h)	60
Self-study hours (h)	120

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Topics of Virtual Reality (121268802)	5th semester	6th semester	0	1
Exam Advanced Topics of Virtual Reality (121268801)	5th semester	6th semester	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Topics of Virtual Reality	5th semester	6th semester	-	3

+ Advanced Techniques in Physically-Based Animation (1212692)

Module titel	Advanced Techniques in Physically-Based Animation (Compulsory elective subject)
Identifier	1212692
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Multibody systems, simulation of joints, deformable solids, finite element methods, volume conservation, simulation of incompressible fluids using Lagrangian approaches, viscosity, surface tension, simulation of fractures
Learning objective	Knowledge: understanding of advanced techniques for the simulation of multibody systems, deformable solids and fluids, experience in the animation of complex physical behavior of different materials, understanding of collision handling. | Skills: implementation of the introduced techniques. | Competences: analysis of problems in the area of physically-based animation, choice of suitable methods to solve specific problems in this area, evaluation of simulation methods, extension of the introduced methods by own ideas
Requirements	None.
(recommended) Requirements	None.
References	Will be announced in the lecture.
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Stephen Bender
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Advanced Techniques in Physically-Based Animation (1212692)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Advanced Techniques in Physically-Based Animation (121269202)	1st semester	no semester recommended	0	1
Exam Advanced Techniques in Physically-Based Animation (121269201)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Advanced Techniques in Physically-Based Animation	1st semester	no semester recommended	-	3

+ Game AI (KP20913)

Module titel	Game AI (Compulsory elective subject)
Identifier	KP20913
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Überblick über die Geschichte der Spiel-KI, wichtige Begriffe und Konzepte, Rückwärtsinduktion und den Minmax-Algorithmus, Alpha-Beta-Beschneidung, traditionelle Baumsuchalgorithmen, Monte-Carlo-Baumsuche, Pfadplanung und den A*-Algorithmus, Bewegungsplanung, räumliches Clustering, selbstorganisierende Karten, deterministische finite Zustandsmaschinen, Fuzzy-Logik und Fuzzy-Control, Wahrscheinlichkeitstheorie und Bayes'sche Netze, Markov-Ketten, versteckte Markov-Modelle, Verstärkungslernen, TD-Lernen, Q-Lernen, genetische Algorithmen
Learning objective	Erwerb von Kenntnissen zu Methoden der künstlichen Intelligenz und des maschinellen Lernens, die es erlauben, kuenstliche Agenten mit Verhaltensweisen auszustatten; Erwerb von Kenntnissen zur praktischen Implementierung entsprechender mathematische Methoden und Algorithmen
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Bauckhage
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ Game AI (KP20913)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Game AI (Exam) (KP2091301)	no semester recommended	no semester recommended	8	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Game AI (Lecture)	no semester recommended	no semester recommended	-	6

+ Geometry Processing (1215696)

Module titel	Geometry Processing (Compulsory elective subject)
Identifier	1215696
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	Methods for the generation of polygonal meshes (laser scanning, registration and integration of mesh patches, etc.), optimization of polygonal meshes(surface smoothing, remeshing, decimation, refinement), hierarchical representations (coarse-to-fine and fine-to-coarse hierarchies), mesh editing approaches, parametrization and texturing, efficient data structures and mesh compression.
Learning objective	Upon successful completion of the module, students should have the following knowledge: Techniques for the generation of highly detailed three-dimensional models of real objects, current algorithms for the optimization, modeling and parameterization of geometry data with a focus on polygonal meshes. Students should be able to implement the techniques independently. Based on the learned knowledge and the developed skills, students should be able to: analyze problems in the field of geometry processing, select and apply adequate algorithms to solve these problems, identify strengths and weaknesses of the learned algorithms, and develop ideas to extend and/or improve the learned algorithms.
Requirements	None.
(recommended) Requirements	Knowledge of “Computer Graphics”, Knowledge about “Algorithms and Data Structures”, and “Linear Algebra”.
References	Botsch, Kobbelt, Pauly, Alliez, Levy: Polygon Mesh Processing
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Leif Kobbelt
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Geometry Processing (1215696)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Geometryprocessing (121569602)	1st semester	no semester recommended	0	2
Exam Geometry Processing (121569601)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Geometry Processing	1st semester	no semester recommended	-	3

+ Foundations of Audio Signal Processing (KP20924)

Module titel	Foundations of Audio Signal Processing (Compulsory elective subject)
Identifier	KP20924
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Theoretical introduction to analog and digital Signal Processing; Fourier Transforms; Analog to digital Conversion; Digital Filters; Audio Signal Processing Applications; Filter banks; Windowed Fourier Transform; 2D-Signal Processing
Learning objective	Knowledge: Theoretical knowledge on analog and digital Signal Processing; Fourier Transforms; Analog-to-Digital Conversion; Digital Filters; Audio Signal Processing tasks; Filter banks; Windowed Fourier Transform (WFT/STFT); 2D Signal Processing. | Skills: Solving basic tasks in the area of (Audio) Signal Processing; Implementing basic signal processing algorithms, e.g., in Matlab. | Competences: Understanding basic relationships in the area of (Audio) Signal Procassing; Analyzing and Solving Signal Processing Problems; Presentation Skills; Discussion of Solutions in Groups
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	apl. Professor Dr. rer. nat. Frank Kurth
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Foundations of Audio Signal Processing (KP20924)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Foundations of Audio Signal Processing (Exam) (KP2092401)	no semester recommended	no semester recommended	6	-

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Foundations of Audio Signal Processing (Lecture)	no semester recommended	no semester recommended	-	4

+ Humanoid Robotics (KP20905)

Module titel	Humanoid Robotics (Compulsory elective subject)
Identifier	KP20905
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	This lecture covers techniques for humanoid robots such as perception, navigation, and motion planning. In more detail, topics include self-calibration with least squares, 3D environment representations, probabilistic self-localization, footstep planning, whole-body motion planning, and walking.
Learning objective	Knowledge: Deep understanding of important techniques relevant for humanoid robots operating in human environments. Skills: Implementation of perception, navigation, and motion planning algorithms for humanoid robots, the ability to analyze problems, communicative skills: oral and written presentation of solutions, discussions in small teams. Competences: Understanding the functioning of humanoid robots and programming humanoid robots.
Requirements	None.
(recommended) Requirements	Mathematical understanding.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	-
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Humanoid Robotics (KP20905)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Humanoid Robotics (KP2090501)	no semester recommended	no semester recommended	6	4

+ Intelligent Learning and Analysis Systems: Machine Learning ...

Module titel	Intelligent Learning and Analysis Systems: Machine Learning (Compulsory elective subject)
Identifier	KP20914
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Types of learning and analysis tasks, most important non-parametric and parametric methods for supervised learning (e.g., decision trees, rules, linear methods, neural networks, neighbourhood methods, kernel methods, probabilistic approaches), reinforcement learning, evaluation and learning theory.
Learning objective	Knowledge: • This module is one of two complementary modules in which students gain an understanding of the most important paradigms and methods of intelligent learning systems as they are used in data analysis and/or for implementing adaptive behaviour (machine learning, data mining, knowledge discovery in databases). This module concentrates on the core task of predictive learning from examples and on agent learning, and teaches the main classes of algorithms (version space algorithms, decision tree learning, k-nearest neighbourhood, probabilistic learning, kernel methods, artificial neural networks, deep learning, computational learning theory) for these tasks. Skills: • Reasoning about formal concepts, formal analysis of algorithms for machine learning. • Usage of standard toolboxes for machine learning. Competences: • At the end of the module, students will be capable of choosing appropriate methods and systems for particular machine learning applications and use them to arrive at convincing results, and will know where to start whenever adaptation or further development of algorithms and systems is necessary.
Requirements	None.
(recommended) Requirements	Prior knowledge of probability theory, linear algebra, formal aspects of algorithms, artificial intelligence, information systems and databases.
References	Tom Mitchell, Machine Learning, McGraw-Hill, 1997; Ian Witten, Eibe Frank, Data Mining, Morgan Kauffmann, 2000; Christopher Bishop: Pattern Recognition and Machine Learning, Springer, 2006; Michael J. Kearns and Umesh Vazirani: An Introduction to Computational Learning Theory, MIT Press, 1994
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Professor Dr. rer. nat. Stefan Wrobel
ECTS Credits	6
Contact time (WSH)	4

+ Intelligent Learning and Analysis Systems: Machine Learning ...

Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Intelligent Learning and Analysis Systems: Machine Learning (Exam) (KP2091401)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Intelligent Learning and Analysis Systems: Machine Learning (Lecture)	no semester recommended	no semester recommended	-	4

+ Introduction to Sensor Data Fusion (KP21707)

Module titel	Introduction to Sensor Data Fusion (Compulsory elective subject)
Identifier	KP21707
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Sensor data fusion is an omnipresent phenomenon that existed prior to its technological realization or the scientific reaction on it. In fact, all living creatures, including human beings, by nature or intuitively perform sensor data fusion. Each in their own way, they combine or fuse sensations provided by different and mutually complementary sense organs with knowledge learned from previous experiences and communications from other creatures. As a result, they produce a mental picture of their individual environment, the basis of behaving appropriately in their struggle to avoid harm or successfully reach a particular goal in a given situation. Sensor Data Fusion is the process of combining incomplete and imperfect pieces of mutually complementary sensor information in such a way that a better understanding of an underlying real-world phenomenon is achieved. Typically, this insight is either unobtainable otherwise or a fusion result exceeds what can be produced from a single sensor output in accuracy, reliability, or cost. Appropriate collection, registration and alignment, stochastic filtering, logical analysis, space-time integration, exploitation of redundancies, quantitative evaluation, and appropriate display are part of Sensor Data Fusion as well as the integration of related context information. Today, Sensor Data Fusion is evolving at a rapid pace and present in countless everyday systems and civilian products.
Learning objective	The learning objectives include Kalman filter based extensions for state estimation using Bayes methods. This includes the incorporation of false alarms, probability of detection, multiple evolution models and non-linear filtering.
Requirements	None.
(recommended) Requirements	None.
References	W. Koch, Tracking and Sensor Data Fusion: Methodological Framework and Selected Applications. Springer, 2014.
Language	English
Grading	Written exam (100 %).
Miscellaneous	-
Module coordinator	Dr. rer. nat. Felix Govaers & apl. Prof. Dr. Wolfgang Koch
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60

+ Introduction to Sensor Data Fusion (KP21707)

Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Sensor Data Fusion (Exam) (KP2170701)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Introduction to Sensor Data Fusion	no semester recommended	no semester recommended	-	4

+ iOS Application Development (1215681)

Module titel	iOS Application Development (Compulsory elective subject)
Identifier	1215681
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	In this class you learn how to develop mobile application on iOS devices. It covers the following topics: Introduction of the programming language Swift, Xcode, Storyboards, Model-View-Controller for iOS, App Frameworks (e.g. UiKit, Foundation), Debugging with Instruments, Basis iOS Development Frameworks (e.g. MapKit, CoreData, Core Location), iOS Graphics and Games Frameworks (e.g. Sprite Kit, Scene Kit), Publish Apps in the AppStore.
Learning objective	Knowledge: On successful completion of this module, students should be able to define the structure of a modern mobile application SDK, recall mobile application design guidelines and explain key software architecture concepts heavily used in the iOS SDK. Furthermore, the will be able to state the differences between mobile and desktop computing and provide an overview of the frameworks provided by the iOS SDK | Skills: They should be able to effectively implement their own iOS Apps, use the iOS development environment in depth and apply an iterative software development process. | Competences: Based on the knowledge and skills acquired students will reach the competence of communicating/ working in a team, of applying the design guidelines to a specific application scenario and of setting up a development plan for a defined application to convincingly present their results.
Requirements	None.
(recommended) Requirements	Knowledge on basics in object-oriented software development.
References	Latest edition of “Programming Fundamentals with Swift” by Matt Neuburg, Publisher: O’Reilly Media
Language	English
Grading	The module examination consists of the following partial qualifications: Presentation and Written homework (17 %); Project work with presentation (50 %); Oral examination (33 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Oliver Borchers & Dr. rer. nat. Simon Völker
ECTS Credits	6
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	45
Self-study hours (h)	135

+ iOS Application Development (1215681)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam iOS Application Development (121568101)	1st semester	no semester recommended	6	0
Exercise iOS Application Development (121568102)	no semester recommended	no semester recommended	-	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture iOS Application Development	1st semester	no semester recommended	-	3

+ Machine Learning (1215744)

Module titel	Machine Learning (Compulsory elective subject)
Identifier	1215744
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Basic concepts: Introduction to Probability Theory, Bayes decision Theory | Probability Density Estimation | Discriminative Methods for Classification: Linear discriminants, Support Vector Machines, AdaBoost | Deep Learning: Multi-Layer Perceptrons, Convolutional Neural Networks, Recurrent Neural Networks
Learning objective	Kenntnisse: Nach erfolgreicher Teilnahme an den Modulveranstaltungen haben die Vorlesungsteilnehmer Kenntnisse und Fähigkeiten in den Themenfeldern, die unter Inhalt beschrieben werden, erworben. | Fertigkeiten: Vorlesungsteilnehmer können Methoden und Techniken, die es einer Maschine ermöglichen, aus Daten zu lernen, herleiten und erklären. Sie kennen die aktuellen Forschungstrends und -entwicklungen. Dadurch sind sie in der Lage, die grundlegenden Machine Learning Techniken, die für diese Fähigkeiten benötigt werden, auszuwählen. | Kompetenzen: Vorlesungsteilnehmer sind in der Lage, die behandelten Methoden selbstständig auf reale Probleme anzuwenden. Sie sind in der Lage, die vorgestellten Algorithmen selbst zu implementieren und diese in einer Programmiersprache ihrer Wahl umzusetzen.
Requirements	None.
(recommended) Requirements	Basic knowledge in Linear Algebra, Probability Theory, and Statistics is recommended.
References	C.M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006. | I. Goodfellow, Y. Bengio, A. Courville, Deep Learning, 2016.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. sc. techn. Bastian Leibe
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Machine Learning (1215744)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Machine Learning (121574402)	1st semester	no semester recommended	0	1
Exam Machine Learning (121574401)	1st semester	no semester recommended	6	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Machine Learning	1st semester	no semester recommended	-	3

+ Pattern Recognition (I) (KP20906)

Module titel	Pattern Recognition (I) (Compulsory elective subject)
Identifier	KP20906
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	Introduction to linear algebra, introduction to probability theory, least squares techni-ques, maximum likelihood techniques, Bayesian inference, aspects of learning theory, data clustering, the EM algorithm and Gaussian mixture models, linear discriminant analysis, the curse of dimensionality and dimensionality reduction, constrained opti-mization, Lagrange multipliers, KKT conditions, gradient descend techniques, gradient free optimization, support vector machines, the kernel trick, perceptron learning, Heb-bian learning, multilayer perceptrons and backpropagation.
Learning objective	Acquisition of knowledge of methods of statistical pattern analysis and machine learning; acquisition of knowledge for the practical implementation of corresponding mathematical methods and algorithms.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Bauckhage
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ Pattern Recognition (I) (KP20906)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Pattern Recognition (I) (KP2090601)	no semester recommended	no semester recommended	8	6

+ Pattern Recognition (II) (KP20908)

Module titel	Pattern Recognition (II) (Compulsory elective subject)
Identifier	KP20908
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	Topics in clude pattern recognition in dynamic data, advanced Bayesian methods, modern neural architectures, recurrent neural networks and machine learning engineering
Learning objective	Learning objectives include theoretical foundations of machine learning for pattern recognition, the ability to identify which methods applies to what kind of scenario, the ability to practically apply methods and to implement pattern recognition systems
Requirements	None.
(recommended) Requirements	Foundational knowledge of Pattern Recognition.
References	Available on http://www.b-it-center.de/b-it-programmes/teaching-material/p3ml/
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Christian Bauckhage
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Pattern Recognition (II) (KP2090801)	no semester recommended	no semester recommended	8	6

+ Pattern Recognition (II) (KP20908)

+ Pattern Matching and Machine Learning for Audio Signal ...

Module titel	Pattern Matching and Machine Learning for Audio Signal Processing (Compulsory elective subject)
Identifier	KP20929
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Foundations of discrete audio signal analysis revisited; audio pattern matching; audio retrieval; introduction to machine learning and classifiers; discriminative and generative classifiers; Hidden Markov Models; Support Vector machines; Neural Networks and Deep Learning
Learning objective	Knowledge: Theoretical knowledge Pattern Matching and Machine Learning. | Skills: Solving basic tasks in the area of Pattern Matching and Machine Learning; Implementing basic retrieval and classification algorithms, e.g., in Matlab. | Competences: Understanding basic relationships in the area of Pattern Matching and Machine Learning; Analyzing and Solving Signal Processing Problems; Presentation Skills; Discussion of Solutions in Groups
Requirements	None.
(recommended) Requirements	Knowledge about Foundations of Audio Signal Processing recommended.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	apl. Professor Dr. rer. nat. Frank Kurth
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Pattern Matching and Machine Learning for Audio Signal Processing (Exam) (KP2092901)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Pattern Matching and Machine Learning for Audio Signal Processing (Lecture)	no semester recommended	no semester recommended	-	4

+ User Centered Technology Design (KP20934)

Module titel	User Centered Technology Design (Compulsory elective subject)
Identifier	KP20934
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	This course focuses on how to design technology in a user-centered way, i.e. keeping the user always in focus. You will conduct small research projects to solve a concrete problem or challenge from some field of life. Each student/team will experience applied research in an iterative product design and software engineering process. The iterations cover steps such as: Scenario thinking, Requirement analysis and identification of user needs, Use-cases and architecture specification, User-interface design, Implementation of prototypes, Usability evaluation. Each student/team has to run through these steps several times during the project. The supervisors will guide the teams in each step and provide appropriate advice in each of the weekly meetings. At the end of the course students are expected to deliver a presentation and demonstration of the prototype. There are a total of 30 minutes for each group, including questions.
Learning objective	Students will acquire or strengthen a set of highly relevant qualifications. Knowledge: Conduct applied research, Deeply understand at least one field or problem of everyday life, Learn and apply innovation and creativity techniques, Learn and apply methodological knowledge, Learn to prototype at different levels and methods | Skills: Work in a team and take over responsibility, Learn to work with people, Learn to present and support your ideas in front of a critical audience | Competences: Gain practical experience with software engineering tools, Work with state-of-the-art technology, Apply methodological knowledge.
Requirements	None.
(recommended) Requirements	Knowledge of 'Designing Interactive Systems I'.
References	Shiv & Fedorikhin Experiment; Heart and Mind in Conflict: the Interplay of Affect and Cognition in Consumer Decision Making; Baba Shiv and Alexander Fedorikhin, Journal of Consumer Research, Vol. 26, No. 3 (December 1999), pp. 278-292 http://www.jstor.org/stable/10.1086/209563; Sketching User Experiences: Getting the Design Right and the Right Design Bill Buxton Morgan Kaufmann; 1 edition (April 11, 2007); ISO9241 Process Model ISO 9241-210:2010 Ergonomics of human-system interaction -- Part 210: Human-centred design for interactive systems https://www.iso.org/standard/52075.html; Context and Questions for semi-structured interviews; DAkkS Usability Guidelines (German), https://www.dakks.de/content/leitfaden-usabilityPersonasThe Inmates Are Running the Asylum Alan Cooper, Macmillan Publishing Co., Inc. Indianapolis, IN,USA©1999ISBN:0672316498; Task models; Allgemeine Arbeitspsychologie: Psychische Regulation von Tätigkeiten Winfried Hacker,Pierre Sachse, Hogrefe Verlag; Auflage: 3 (8. November 2013); User Needs and Requirements Anything from ProContext.de (they developed the method) e.g. http://www.procontext.com/aktuelles/2012/06/nutzungskontext-erfordernisse-anforderungen-und-loesung-das-arbeitsmodell-des-usability-engineering.html; The Volere Template (Snow card) Mastering the Requirements Process: Getting Requirements Right. Suzanne Robertson and James Robertson, Addison-Wesley Professional; 3 edition (August 16, 2012)
Language	English
Grading	The module examination consists of the following partial qualifications: Written homework (20 %); project work (30 %); written exam or oral examination (50 %). Students must pass written homework to be admitted to the examination.

+ User Centered Technology Design (KP20934)

Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Matthias Jarke & Sarah Suleri, M.Sc. RWTH
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
User Centered Technology Design (Exam) (KP2093401)	1st semester	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
User Centered Technology Design (Lecture)	1st semester	no semester recommended	-	4

+ Physically-Based Animation (1215862)

Module titel	Physically-Based Animation (Compulsory elective subject)
Identifier	1215862
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Basics of physically-based animation, particle systems, rigid bodies, simulation of deformable solids using discrete and continuous models, fluid simulation, collision detection and collision response.
Learning objective	Knowledge: understanding of state-of-the-art simulation methods for rigid bodies, deformable solids and fluids, experience in real-time simulation in computer graphics, collision detection algorithms. | Skills: implementation of the introduced techniques. | Competences: analysis of problems in the area of physically-based animation, choice of suitable methods to solve specific problems in this area, evaluation of simulation methods, extension of the introduced methods by own ideas.
Requirements	None.
(recommended) Requirements	Basic knowledge of numerics, algorithms and data structures and computer graphics.
References	Will be announced in the lecture.
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Stephen Bender
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

+ Physically-Based Animation (1215862)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Physically Based Animation (121586202)	1st semester	no semester recommended	0	1
Exam Physically-Based Animation (121586201)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Physically Based Animation	1st semester	no semester recommended	-	3

+ Real-time Graphics (1215680)

Module titel	Real-time Graphics (Compulsory elective subject)
Identifier	1215680
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	The course “Real-time Graphics” covers the following subjects: real-time physics (particle systems, deformable objects (e.g. cloth simulation), rigid bodies and collision detection, fluid simulation) | animation (skeletal/character animation, facial animation) | Rendering with OpenGL (Introduction to OpenGL, Rendering paradigms, Material rendering, Shadows, Transparency, Post-processing, GPU Architectures)
Learning objective	After finishing this course, students should have knowledge of the basic techniques required for creating practical computer graphics applications (e.g. computer animation or computer games). They should have the skills to implement such applications efficiently. Furthermore they should have the compentences to distinguish and evaluate the required algorithms regarding their individual advantages and disadvantages.
Requirements	None.
(recommended) Requirements	Knowledge of “Computer Graphics”.
References	Game Coding Complete (4th Edition), Mike McShaffry, David Graham | Game Engine Architecture (2nd Edition), Jason Gregory | Game Physics Cookbook, Gabor Szauer | Real-Time Rendering, (3rd Edition), Tomas Akenine-Möller, Eric Haines, Naty Hoffmann | Game Programming Patterns, Robert Nystrom
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Leif Kobbelt
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Real-time Graphics (1215680)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Real-time Graphics (121568001)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Real-time Graphics	1st semester	no semester recommended	-	3
Exercise Real-time Graphics	1st semester	no semester recommended	-	2

+ Research Focus Class on Learning Technologies (1222419)

Module titel	Research Focus Class on Learning Technologies (Compulsory elective subject)
Identifier	1222419
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	This research-oriented course is aimed at students who are interested in current issues, developments and research in the field of modern learning technologies. A selected topic from one of the following areas of learning technologies will be discussed: Learning Analytics, Learning Games, Mobile Learning, Blended Learning, Computer Science Didactics etc. The first step will be an introduction to the current state of research in the selected subject area. In the following, each student should identify a question (research idea) in the subject area under guidance and familiarise themselves with it and present it to the other participants. This concept phase is followed by a practical phase in which the students work out their research idea (prototype implementation, analysis, simulation, etc.) and evaluate it. The exact procedure can vary from semester to semester and depending on the subject area.
Learning objective	Knowledge: Basic knowledge of current research topics in the field of learning technologies and/ or computer didactics. Knowledge of basic web technologies and their applications for learning and teaching through technology. | Skills: Knowledge of scientific methods for the development of own results, both theoretical and practical. | Competences: In-depth knowledge of a selected, current topic; ability to independently familiarise oneself with a research topic.
Requirements	None.
(recommended) Requirements	Knowledge from the courses "Introduction to Web Technologies" and/or "Learning Technologies".
References	Current literature on selected topics; will be announced in the course.
Language	German/English
Grading	The module examination consists of the following partial qualifications: Project work or practical lab (70 %); Colloquium (30 %).
Miscellaneous	-
Module coordinator	-
ECTS Credits	6
Contact time (WSH)	2
Examination duration (min)	-
Total hours (h)	180
Contact hours (h)	30
Self-study hours (h)	150

+ Research Focus Class on Learning Technologies (1222419)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Research Focus Class on Learning Technologies (122241901)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Course Research Focus Class on Learning Technologies	no semester recommended	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

+ Semantic Web (1212675)

Module titel	Semantic Web (Compulsory elective subject)
Identifier	1212675
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	As part of the W3C Semantic Web initiative, standards and technologies have been developed for machine-readable exchange of data, information and knowledge on the Web. These standards and technologies are increasingly being used in applications and have already led to a number of exciting projects (e.g. DBpedia, semantic wiki or commercial applications such as schema.org, OpenCalais, or Google's KnowledgeGraph). The module provides a theoretically grounded and practically oriented introduction to this area. The topics discussed within the lecture include History of the Web and Semantic Web; RDF syntax and data model; RDF Schema and formal semantics of RDF(S); Ontologies in OWL and formal semantics of OWL; RDF databases, triple and knowledge stores, query languages; Linked Data Web and Semantic Web applications.
Learning objective	Knowledge: After the module, the students will know the following: The Why and How of Semantic Web applications; The foundational technologies and where they are applied; How to manage and query Semantic Web data; The knowledge representation formalisms in the Semantic Web field; some applications. | Skills: After the module, the students should be able to Setup an RDF Database, RDF Querying, Define ontologies in RDF(S) and OWL. | Competences: Design and build a system for the management and processing of Semantic Web data, Manage and use the system, Assess the advantages and disadvantages of Semantic Web technologies for particular applications
Requirements	None.
(recommended) Requirements	Knowledge of Database system theory and practice.
References	-
Language	English
Grading	Written exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Stefan Decker
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	90-120 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

+ Semantic Web (1212675)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Semantic Web (121267502)	1st semester	no semester recommended	0	1
Exam Semantic Web (121267501)	1st semester	no semester recommended	4	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Semantic Web	1st semester	no semester recommended	-	2

+ Social Networks (7016926)

Module titel	Social Networks (Compulsory elective subject)
Identifier	7016926
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This module gives an overview on the analysis of social networks. It includes foundations of social networks (definitions, network representation, local structures), basic network algorithms (shortest path, clustering coefficient, ...), centrality measures for social networks (PageRank, betweenness centrality,...), community detection methods, emerging phenomena in empirical social networks (power law, small world, homophily, …), network models (random graphs, preferential attachment, ...), graph robustness and dynamics on networks, epidemics, and information cascades.
Learning objective	Knowledge: On successful completion of this module, students should know about fundamental concepts and algorithms of network analysis and should have learned about emerging phenomena in empirical networks. Students should also obtain an overview on state-of-the-art analysis tools for social networks. | Skills: Students learn to analyze empirical social networks with respect to their structure, compute network properties, identify central nodes, and investigate network dynamics and to be able to apply state-of-the libraries for analyzing social networks. | Competences: Students can competently apply methods from the domain of social network analysis to different application fields.
Requirements	-
(recommended) Requirements	Basic programming skills as taught in "Programmierkurs (Java)" and “Scientific Programming in Python", basic knowledge about statistics and knowledge from courses „Datenstrukturen und Algorithmen“ as well as „Datenbanken und Informationssysteme” or equivalent.
References	-
Language	English
Grading	The grading results from the final exam of this module. The exam can be a written or an oral exam. The final form of the examination is announced at the beginning of the lecture. Homework may count towards the final examination grade. The exam is done at the end of the lecture period.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation: LeMa-Team Philosophische Fakultät, modulangebotsorganisation@fb7.rwth-aachen.de Modulverantwortlicher: Univ.-Prof. Dr. techn. Markus Strohmaier
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	-
Total hours (h)	180
Contact hours (h)	75

+ Social Networks (7016926)

Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Social Networks (701692601)	1st semester	no semester recommended	6	0
Exercise Social Networks (701692602)	1st semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung Social Networks	1st semester	no semester recommended	-	3

RWTH AACHEN UNIVERSITY

+ Statistical Classification and Machine Learning (1215840)

Module titel	Statistical Classification and Machine Learning (Compulsory elective subject)
Identifier	1215840
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Introduction/motivation. | Bayes' decision rule. | Training and learning. | Model-free methods. | Neural networks. | Mixture densities and cluster analysis. | Stochastic finite automata (hidden Markov models). | Sequence classification (Master only). | Feature extraction (Maser only).
Learning objective	Knowledge: On successful completion of this module, students should be able to: develop intuition for statistical classification methods. | have command of algorithms and principles of statistical classification. | describe the various applications of state-of-the-art methods of statistical classification. | describe the fundamental properties and methods of statistical classification. | describe the methods for training a statistical classification system. | describe the trade-off between system complexity and performance in advanced statistical classification system. | describe methods for sequence classification (Master only). | describe methods for feature extraction (Master only). Skills: They should be able to: implement advanced methods of statistical classification (Master only: incl. sequence classification and feature extraction). | to train the parameters of a statistical classification system using appropriate training methods (Master only: incl. sequence classification and feature extraction). | apply methods of statistical classification (Master only: incl. sequence classification and feature extraction). | measure and analyze the performance of a statistical classification system in complex real-life applications (Master: incl. sequence classification and feature extraction). | have command over the contents and fundamental techniques of this module. | transfer the conveyed content by exemplary solution of special statistical classification problems (Master only: incl. sequence classification and feature extraction). Competences: Based on the knowledge and skills acquired they should: have an overview of advanced methods in statistical classification (Master only: incl. sequence classification and feature extraction). | be able to apply advanced methods of statistical classification (Master only: incl. sequence classification and feature extraction). | be in a position to analyze specific problems in a real-life application of a statistical classification system (Master only: incl. sequence classification and feature extraction).
Requirements	None.
(recommended) Requirements	None.
References	R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification. 2nd ed., J. Wiley, New York, NY, 2001. | K. Fukunaga: Introduction to Statistical Pattern Recognition. Academic Press, New York, NY, 1990.
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Hermann Ney
ECTS Credits	8
Contact time (WSH)	6

+ Statistical Classification and Machine Learning (1215840)

Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Statistical Classification and Machine Learning (121584002)	5th semester	no semester recommended	0	2
Exam Statistical Classification and Machine Learning (121584001)	5th semester	no semester recommended	8	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Statistical Classification and Machine Learning	5th semester	no semester recommended	-	4

+ Statistical Methods in Natural Language Processing (1215695)

Module titel	Statistical Methods in Natural Language Processing (Compulsory elective subject)
Identifier	1215695
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Bachelor/Master
Content	Introduction/Motivation | Linguistic and Statistical Foundations | Text and Document Classification | Language Modelling | Part-of-Speech (POS) Tagging | Information Extraction by Tagging | Probabilistic Context Free Grammars and Parsing | Machine Translation
Learning objective	Knowledge: On successful completion of this module, students should be able to:describe the various applications of advanced state-of-the-art methods of Natural Language Processing. | describe the fundamental properties and methods of Natural Language Processing. | describe the advanced methods for training a Natural Language Processing: system. | describe the trade-off between system complexity and performance in an advanced Natural Language Processing system. Skills: They should be able to:to train the parameters of a Natural Language Processing system using advanced training methods. | apply and implement advanced methods of Natural Language Processing | measure and analyse the performance of a Natural Language Processing | system in complex real-life applications. Competences: Based on the knowledge and skills acquired they should:have an overview of advanced methods in Natural Language Processing. | be able to apply advanced methods of Natural Language Processing. | be in a position to analyze specific problems in a real-life application of Natural Language Processing systems.
Requirements	None.
(recommended) Requirements	Knowledge from „Einführung in die Stochastik“, „Datenstrukturen und Algorithmen“, „Formale Systeme, Automaten, Prozesse“.
References	C. D. Manning, H. Schütze: Foundations of Statistical Natural Language Processing. MIT Press, Cambridge, MA, 1999. | D. Jurafsky, J. H. Martin: Speech and Language Processing. Prentice Hall, Englewood Cliffs, NJ, 2000. | Folien/Lecture Notes: http://www-i6.informatik.rwth-aachen.de/web/Teaching/
Language	German/English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Hermann Ney
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90

+ Statistical Methods in Natural Language Processing (1215695)

Self-study hours (h)	150

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Statistical Methods in Natural Language Processing (121569502)	1st semester	no semester recommended	0	2
Exam Statistical Methods in Natural Language Processing (121569501)	1st semester	no semester recommended	8	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Statistical Methods in Natural Language Processing	1st semester	no semester recommended	-	4

+ Technical Neural Nets (KP20916)

Module titel	Technical Neural Nets (Compulsory elective subject)
Identifier	KP20916
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	The lecture gives an overview over the most important technical neural networks and neural paradigms. The following topics will be explained in detail: Perceptron, multi-layer perceptron (MLP), radial-basis function nets (RBF), Hopfield nets, self organizing feature maps (SOMS, Kohonen), adaptive resonance theory (ART), learning vector quantization, recurrent networks, back-propagation of error, reinforcement learning, Q-learning, support vector machines (SVM), Neocognitron, Convolutional Neural Networks, Deep Learning. The voluntary exercises are arranged to intensify the work with the research topics presented in the lecture. You will get weekly paper-and-pencil assignments that are designed to be worked on in two person groups and completed within one week. Your results of the assignments shall be presented and discussed during the exercise group to practice and improve your oral presentation skills. The paper and pencil assignments are accompanied by small programming tasks to be completed using individually implemented programms and stat of the art simulation tools. Although the participation is on a voluntary basis, the points from the paper and pencil assignments reached are a good indicator to judge your performance with respect to the examination.
Learning objective	Detailed knowledge of the most important neural network approaches and learning algorithms and its fields of application. Knowledge and understanding of technical neural networks as Non-Von Neumann computer architectures similar to concepts of brain functions at different stages of development The students will be capable to propose several paradigms from neural networks that are capable to solve a given task. They can discuss the pro and cons with respect to efficency and risk. They will be capable to plan and implement a small project with state of the art neural network solutions.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Nils Goerke
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Technical Neural Nets (KP20916)

Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Technical Neural Networks (Exam) (KP2091601)	no semester recommended	no semester recommended	6	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Technical Neural Networks (Lecture)	no semester recommended	no semester recommended	-	4

RWTH AACHEN UNIVERSITY

+ Semantic Data Web Technologies (KP20931)

Module titel	Semantic Data Web Technologies (Compulsory elective subject)
Identifier	KP20931
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	As part of the W3C Semantic Web initiative standards and technologies have been developed for machine-readable exchange of data, information and knowledge on the Web. These standards and technologies are increasingly being used in applications and have already led to a number of exciting projects (e.g., community projects such as DBpedia or commercial applications such as schema.org, OpenCalais, or Google's knowledge graph). The module provides a theoretically grounded and practically oriented introduction to this area. The topics discussed within the lecture include: Introduction to the (Semantic) Web, RDF (Resource Description Framework) data model, RDF Serializations (RDF/XML, Turtle, N3, RDFa, JSON-LD), RDF Schema (RDFS), RDF and RDFS Semantics, OWL Syntax and Intuition, OWL Semantics and Reasoning, Rules in the Semantic Web (DL Rules, SWRL, RIF), PARQL Query Language, Linked (Open) Data, RDB2RDF (Mapping relational databases to RDF)
Learning objective	The goal of this lecture is to impart knowledge on the fundamentals, technologies and applications of the Semantic Web and on retrieving information from semantic web data sources. As part of the lecture the basic concepts and standards for semantic technologies are explained.
Requirements	None.
(recommended) Requirements	Previous knowledge of relational databases and SQL, of XML, and of first-order predicate logic will facilitate the understanding of parts of the module, but the necessary prerequisites will be introduced during this module.
References	Pascal Hitzler, Markus Krötzsch, Sebastian Rudolph, Foundations of Semantic Web Technologies, Chapman & Hall/CRC, 2009; Wir empfehlen außerdem, die W3C-Spezifikationen von RDF, seine Serialisierungen, RDF-Schema, OWL und SPARQL zu berücksichtigen.
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jens Lehmann
ECTS Credits	4
Contact time (WSH)	4
Examination duration (min)	90
Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

+ Semantic Data Web Technologies (KP20931)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Semantic Data Web Technologies (Exam) (KP2093101)	1st semester	no semester recommended	4	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Semantic Data Web Technologies (Lecture)	1st semester	no semester recommended	-	4

+ The Logic of Knowledge Bases (1211393)

Module titel	The Logic of Knowledge Bases (Compulsory elective subject)
Identifier	1211393
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Bachelor/Master
Content	First-Order Logic, The Modal Logic KL, Finite vs. Infinite representability, A Representation Theorem, Only Knowing, Autoepistemic Reasonining, Tractable Reasosoning, Situation Calculus
Learning objective	Knowledge: This lecture is about the logical foundations of knowledge bases. At the end of the course the student will able to characterize the functional view of knowledge bases, distinguish between the knowledge and symbol level, describe why epistemic query languages are needed in the presence of incomplete knowledge, reduce epistemic queries to first-order queries, appreciate the computational complexity inherent in incomplete information. | Skills: The student will be able to use modal logic to analyze the functional and computational requirements of knowledge-based systems, which need to deal with incomplete information. | Competences: The student will be able to play a leading role in the design team of knowledge-based systems.
Requirements	None.
(recommended) Requirements	Basic knowledge of Mathematical logic and/or knowledge representation or comparable knowledge.
References	Lecture Notes (Transparencies); Hector J. Levesque and Gerhard Lakemeyer, The Logic of Knowledge Bases, MIT Press, 2001.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Gerhard Lakemeyer Ph. D.
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ The Logic of Knowledge Bases (1211393)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise The Logic of Knowledge Bases (121139302)	1st semester	no semester recommended	0	2
Exam The Logic of Knowledge Bases (121139301)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture The Logic of Knowledge Bases	1st semester	no semester recommended	-	3

RWTH AACHEN UNIVERSITY

+ Virtual Reality (1211909)

Module titel	Virtual Reality (Compulsory elective subject)
Identifier	1211909
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This course teaches the basic methods for a simulation of virtual environments and introduces to Virtual Reality applications in the fields of mechanical engineering, simulation science, and medicine. The course comes along with practical presentations and covers the following topics: The nature and history of VR, physiological aspects of 3-D visual perception, VR-related computer graphics, stereoscopic projections, projection and interaction hardware, VR displays, motion tracking, collision detection, 3D user interfaces, VR applications in research and industry.
Learning objective	Knowledge: After a successful completion of this module, students should have gained knowledge about the following topics: Characteristic features of Virtual Reality, Basic methods and algorithms of Virtual Reality, 3D interaction, Stereoscopic projections, Efficient methods of collision detection, Motion tracking | Skills: Students should be able to: Systematically evaluate and compare the quality of VR interfaces, Develop concepts of VR interfaces and applications | Competences: Based on the knowledge and the skills, students should be able to: Develop VR techniques and methods to solve technical and scientific problems, and work independently and scientifically in the discipline of Virtual Reality
Requirements	Voraussetzung für die Zulassung zur Prüfung ist das Bestehen von Übungsaufgaben. Details werden in der Vorlesung bekanntgegeben.
(recommended) Requirements	Basic knowledge of Linear Algebra.
References	D. Bowman et al. 3D User Interfaces. Addison-Wesley | K. M. Stanney. Handbook of Virtual Environments. Erlbaum | M.Slater et al. Computer Graphics & Virtual Environments. Addison-Wesley | G. Burdea, P. Coiffet. Virtual Reality Technology. John Wiley & Sons | K.-F. Kraiss (Ed.). Advanced Man Machine Interfaces. Springer | R.S. Kalawski. The Science of Virtual Reality and Virtual Environments. Addison Wesley
Language	German
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Torsten Wolfgang Kuhlen
ECTS Credits	6
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60

+ Virtual Reality (1211909)

Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Virtual Reality (121190902)	1st semester	no semester recommended	0	1
Exam Virtual Reality (121190901)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Virtual Reality	1st semester	no semester recommended	-	3

+ Visual Data Analysis (KP20909)

Module titel	Visual Data Analysis (Compulsory elective subject)
Identifier	KP20909
Version	-
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	This class provides a broad overview of principles and algorithms for data analysis via interactive visualization. Specific topics include perceptual principles, luminance and color, visualization analysis and design, integration of visual with statistical data analy-sis and machine learning, as well as specific algorithms and techniques for the display of multidimensional data, dimensionality reduction, graphs, direct and indirect volume visualization, vector field and flow visualization, as well as tensor field visualization.
Learning objective	Knowledge: Algorithms and techniques for visualization of multidimensional data, graphs, as well as scalar, vector and tensor fields. Skills: Design, implementation and correct use of systems for visual data analysis. Competences: Productive work in small groups, independent solution of practical problems in the field of visual data analysis, critical questioning of visualization designs, presentation of solution strategies and implementations.
Requirements	None.
(recommended) Requirements	Basic knowledge in linear algebra and calculus, as well as proficiency in programming.
References	A.C. Telea, Data Visualization: Principles and Practice. CRC Press, Second Edition, 2015 M. Ward et al., Interactive Data Visualization: Foundations, Techniques, and Applica-tions. CRC Press, 2010 T. Munzner, Visualization Analysis and Design, A K Peters, 2015
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Thomas Schultz & Universitätsprofessor Dr. rer. nat. Reinhard Klein
ECTS Credits	8
Contact time (WSH)	6
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	240
Contact hours (h)	90
Self-study hours (h)	150

+ Visual Data Analysis (KP20909)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Visual Data Analysis (KP2090901)	1st semester	2nd semester	8	6

+ Web Mining (7016927)

Module titel	Web Mining (Compulsory elective subject)
Identifier	7016927
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This module teaches methods and models that allow to investigate how users access information on the World Wide Web. Its contents include data acquisition on the web (weblogs, APIs, web crawling, information extraction), models of information seeking, web access patterns (association rules, sequential patterns, exceptional model mining), sequence modelling and hypothesis testing, web search engines, personalized search, link prediction, and recommendations as well as A/B testing and multi-armed bandits.
Learning objective	Knowledge: After successful completion of this course, students should have knowledge about information seeking models, how search engines on the web work, key algorithms for finding interesting access patterns from weblog data and statistical models for user behaviour. | Skills: Students should be able to use the acquired knowledge to independently and computationally collect and analyse web-related data, and apply their knowledge to propose and describe adequate solutions for web-related mining problems. | Competences: Based on their knowledge and skills, students should be able to acquire knowledge for learning and assessing advanced web mining techniques via literature research, to identify the key elements of a web mining problem setting, and to devise corresponding project plans and implementations.
Requirements	Kenntnisse aus der Programmierung, Statistik, Datenstrukturen und Algorithmen sowie Datenbanken und Informationssysteme.
(recommended) Requirements	Basic programming skills as taught in "Programmierkurs (Java)" and “Scientific Programming in Python", basic knowledge about statistics and knowledge from lectures "Datenstrukturen und Algorithmen" and "Datenbanken und Informationssysteme" or equivalent.
References	-
Language	English
Grading	The grading results from the final exam of this module. The exam can be a written or an oral exam. The final form of the examination is announced at the beginning of the lecture. Homework may count towards the final examination grade. The exam is done at the end of the lecture period.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation: LeMa-Team Philosophische Fakultät, modulangebotsorganisation@fb7.rwth-aachen.de Modulverantwortlicher: Univ.-Prof. Dr. techn. Markus Strohmaier
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180

+ Web Mining (7016927)

Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Web Mining (701692701)	1st semester	no semester recommended	6	0
Exercise Web Mining (701692702)	1st semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Vorlesung Web Mining	1st semester	no semester recommended	-	3

+ Web Science (1212359)

Module titel	Web Science (Compulsory elective subject)
Identifier	1212359
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	With the emerging development and impacts of World Wide Web, Web Science having information and social dimensions has been becoming a new study field in Computer Science. This course repeats fundamental concepts (web centralities &; algorithms, network models and web engineering principles) of Web Science I. We then give an overview on regular and random network models, influence, economic, and biological networks. In the following we study dynamic processes on complex networks (emergence, percolation, epidemics, synchrony, walking and searching, net gain and repeated games). In the engineering part we dig into emerging cloud &; grid computing approaches like GoogleApp, Google Wave (XMPP) and Bittorrent. With the knowledge gained in the preceding chapter we can analyse and engineer advanced web applications like the Wikipedia, personal learning environments and massive 3D multimedia environments.
Learning objective	Knowledge: On successful completion of this module, students should be able to (a) Differentiate the terms and generations of the world wide web, including Internet, social and semantic web, Web Services and Cloud Computing; (b) Recall the fundamental issues of Web Science as a new socio-technical sub discipline of Informatics; (c) Describe strategies like community detection for web data search, mining and web data integration, as well as social community platforms; (d) Describe leading base algorithms (PageRank, HITS) and commercial strategies (Recommender Systems) for web platforms such as Google, Facebook, Amazon, etc.; € Recall theories for the analysis of Web-based social networks, such as Social Network Analysis, Web distributions and Actor-Network Theory. Skills: They should be able to (1) Analyze and apply different algorithms for Web search, mining, integration, and analysis in Matlab; (2) Creatively use advanced Web service development methods on realistic development and consulting projects; (3) Interact socially with other developers and with end users from different cultures in analyzing requirements and problems in the Web; (3O Analyze the dynamics of the Web and its services and platforms. Competences: Based on the knowledge and skills acquired, they should be able to (i) Critically analyze and discuss proposed Web services and changing regulations in the Internet sector and (ii) Cooperate in local and distributed community.
Requirements	None.
(recommended) Requirements	Basics of linear algebra and graph theory as well as foundations of Web programming.
References	-
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. pol. Matthias Jarke
ECTS Credits	6
Contact time (WSH)	4

+ Web Science (1212359)

Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	60
Self-study hours (h)	120

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Web Science (121235902)	1st semester	no semester recommended	0	1
Exam Web Science (121235901)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Web Science	1st semester	no semester recommended	-	3

+ Knowledge Representation (1212361)

Module titel	Knowledge Representation (Compulsory elective subject)
Identifier	1212361
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	First-Order Logic, Resolution, Horn Logic, Procedural Representations, Description Logics, Inheritance Networks, Nonmonotonic Reasononing, Reasoning about Action and Planning
Learning objective	Knowledge: Upon successful completion of this module, the student will be familiar with the basic principles and methods of Knowledge Representation and Reasoning. These include first-order logic and inference by resolution, procedural representations, production systems, description logic, nonmonotonic reasoning, and abduction. | Skills: The student will be able to design knowledge-based systems. In particular, he or she will be able to analyze and cope with the computational complexity of such systems. | Competences: When developing software systems for large applications, the student will be able to identify which parts are best realized using a knowledge-based approach. Moreover, he or she will be able to choose among a number of existing methods to knowledge representation and reasoning and put the chosen methods to practice.
Requirements	None.
(recommended) Requirements	Knowledge of the lecture Mathematical Logic.
References	Lecture Notes (Transparencies; Ron Brachman and Hector J. Levesque, Knowledge Representation and Reasoning, Morgan Kaufmann, 2004.
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Gerhard Lakemeyer Ph. D.
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

+ Knowledge Representation (1212361)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Knowledge Representation (121236102)	1st semester	no semester recommended	0	2
Exam Knowledge Representation (121236101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Knowledge Representation	1st semester	no semester recommended	-	3

+ Mining Media Data (KP22665)

Module titel	Mining Media Data (Compulsory elective subject)
Identifier	KP22665
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	Frequent Itemset Mining, Market Basket Analysis, Associated Rule Mining, Apriori Algorithm, Frequent Pattern Tree, Matrix Factorization, Tensor Factorization, Alternating Least Squares, Gradient Descent Individual Dimensional Scaling, DEDICOM, Evolutionary Strategies, K-Means, Decision Trees, Neural Networks, Churn Prediction, Recommender Systems, Collaborative Filtering, Self-Organizing Maps, Textmining, Stemming, Lemmatization, TF-IDF, Latent Semantic Indexing, Global Vectors, Recurrent Neural Networks, Sentiment Analysis
Learning objective	Knowledge: Students should be able to have a deep understanding of the commonly used data science methods in the are of data mining, explain and evaluate methods for mining massive data, relate the corresponding methods to a given media data mining problem, transfer their data mining and optimization knowledge to other fields (e.g. information retrieval, business intelligence and etc.),learn to rapidly adapt to changing software systems for data management and training machine learning methods. Skill: Students should be able to analyze, design as well as reason about existing and new data mining algorithms, theoretically compare algorithms, strengthen their analytical thinking to solve difficult optimization problems, have acquired the necessary mathematical as well as programming/ IT skills to systematically plan, design and implement small to medium sized data mining projects. Competences: Having completed this lecture, the students will be able to successfully contribute to data mining research, theoretically assess the scalability of already existing methods, connect concepts from machine learning, pattern recognition and data mining for research and development of scalable solutions, contribute to data science projects by proposing applying the learned methods to design and build creative solutions that handle multi-channel input.
Requirements	-
(recommended) Requirements	Basic knowledge of AI, data science, machine learning, and pattern recognition; programming skills; good working knowledge in statistics, linear algebra, and optimization.
References	• Data Mining: Concepts and Techniques, Jiawei Han, Jian Pei, Micheline Kamber ; • Artificial Intelligence: A Guide to Intelligent Systems, Michael Negnevitsky • Pattern Recognition and Machine Learning, Christopher M. Bishop ; • Introduction to Information Retrieval, Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze
Language	English
Grading	Klausur (100 %). ;Voraussetzung für die Zulassung zur Modulprüfung ist das Bestehen von Hausaufgaben.
Miscellaneous	-
Module coordinator	Prof. Dr. Christian Bauckhage
ECTS Credits	4
Contact time (WSH)	3

+ Mining Media Data (KP22665)

Examination duration (min)	60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Mining Media Data - Exam (KP2266501)	no semester recommended	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Mining Media Data – Lecture and exercise	no semester recommended	no semester recommended	-	4

+ Business Process Intelligence (1216958)

Module titel	Business Process Intelligence (Compulsory elective subject)
Identifier	1216958
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This course starts with an overview of approaches and technologies that use event data to support decision making and business process (re)design. Subsequently, the course focuses on process mining as a bridge between data mining and business process modeling. Business Process Intelligence (BPI) and process mining enable engineers to understand, diagnose, improve, and streamline operational processes for a wide variety of organizations and systems (production systems, hospitals, banks, high-tech systems, governments, electronic shops, transportation systems, trading systems, etc.). The course covers the three main types of process mining: process discovery, conformance checking, and enhancement. The course uses many examples using reallife event logs to illustrate the concepts and algorithms. After taking this course, one is able to run process mining projects and have a good understanding of the Business Process Intelligence (BPI) field. Moreover, students will be able to directly apply process mining techniques in all kinds of practical settings, including internships and master projects. | Written homework (DS Assignment 1) contains an analysis of a real-life and/or synthetic data set using the techniques and tools provided in the course. This homework is used to test the understanding of the material. Written homework (DS Assignment 2) contains an analysis of more complex data sets using various data science techniques. This includes interpreting the results and creatively using multiple views of the data. The written exam contains questions to test the theoretical knowledge of the algorithms and techniques learned.
Learning objective	Knowledge: On successful completion of this module, students should be able to: comprehend Petri nets, understand basic process discovery algorithms, understand how to align a process instance or an event log with a process model, being able to consider other perspectives e.g., performance projection on a Petri net and get familiar with concepts like responsible data science and big data in process mining. | Skills: Students should be able to use different process mining tools such as ProM and Disco. Moreover, they are able to filter event logs and understand how different parameters of an algorithm have an effect on the result of the analysis. | Competences: based on the knowledge and skills acquired during this course, students should be able to apply basic process mining algorithms on real industrial problems and answer related questions of business owners that are related to the process.
Requirements	None.
(recommended) Requirements	Prior knowledge in process modeling, logic, programming and databases.
References	The textbook "W. van der Aalst. Process Mining: Data Science in Action. Springer-Verlag, Berlin, 2016" (http://springer.com/9783662498507) is the primary source of information and the lectures will be linked to chapters in the book. Slides, exercises, software and data sets will be provided to participants. The Coursera MOOC on Process Mining https://www.coursera.org/learn/process-mining will provide additional background information in case things are not clear.
Language	English
Grading	The module examination consists of the following partial qualifications: Written homework (40 %); Written exam (60 %). Students must pass all parts of the examination individually to pass the module. It is not possible to transfer parts of the examinations in another semester.
Miscellaneous	-

+ Business Process Intelligence (1216958)

Module coordinator	Universitätsprofessor Professor h. c. Dr. h. c. Dr. ir. Wil van der Aalst
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Business Process Intelligence (121695802)	1st semester	no semester recommended	0	2
Exam Business Process Intelligence (121695801)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Business Process Intelligence	1st semester	no semester recommended	-	3

RWTH AACHEN UNIVERSITY

+ CSCW and Groupware: Concepts and Systems for Computer Supported ...

Module titel	CSCW and Groupware: Concepts and Systems for Computer Supported Cooperative Work (Compulsory elective subject)
Identifier	1215691
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Groupware or CSCW (Computer Supported Cooperative Work) is subject of computer science and other disciplines to support cooperative work of working groups. Current research streams focus the integration of groupware, multi media and telecommunication- and internet services. The lecture presents main concepts and systems of synchronous and asynchronous communication support (e.g. video conferencing, media spaces, and shared workspaces). In addition, the lecture treats cooperation support by workflow-management systems and current trends (CommunityWare, Collaborative Virtual Environments). A special focus is the presentation and discussion of Blockchain technologies and their application in cooperation network.
Learning objective	Knowledge: CSCW Concepts, Methods and Theories; Functionalities and properties of different cooperation support applications; basics of blockchain technologies |Skills: modelling of cooperation solutions; requirement analysis; selection of appropriate coordination solutions; analysis of Blockchain technologies | Competences: Analysis and evaluation of cooperation systems and architectures as well as their properties; Evaluation and rating of Blockchain solutions for different application areas.
Requirements	None.
(recommended) Requirements	None.
References	Papers supporting the different chapters of the lecture will be provided in an eLearning environment
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Wolfgang Prinz Ph. D.
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise CSCW and Groupware (121569102)	1st semester	no semester recommended	0	1
Exam CSCW and Groupware (121569101)	1st semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture CSCW and Groupware	1st semester	no semester recommended	-	2

+ Process Management (1211902)

Module titel	Process Management (Compulsory elective subject)
Identifier	1211902
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	The lecture conveys concepts, methods and languages for the management of processes in enterprises and across cooperating business partners. It covers methods for the gathering, planning, and execution of processes. The module presents modelling methods for different application domains and usage scenarios as well as the support for the operational implementation of processes. Capability maturity models will be discussed as an operational extension for the assessments of process qualities in addition to the mere operational efficiency.| The lecture covers: process management requirements, modelling concepts for process capture and operational support, system technologies for the automation of processes and the implementation of workflows, capability maturity models for process assessment and customisation means.
Learning objective	Knowledge: On successful completion of this module, students know the core concepts of process management and its added value for businesses, different languages for modelling processes and their functional objectives (advantages & disadvantages), design principals of projects for process optimization, different capability maturity models and the potential of process formalisation with regard to performance analysis, automation and functional reuse. | Skills: Students can distinguish different objectives of languages for process modelling as well as different project designs for process optimisation, conceptualise the role and utilization of capability maturity models for process assessment and improvement, design the automation of processes from the concept phase towards the operational implementation | Competencies: Students know how to use modelling tools and languages for the formalization of processes in various domains and contexts, transform informally presented processes into formal process models, automate of process specifications in terms executable workflows, and assess the quality of processes with maturity models
Requirements	None.
(recommended) Requirements	Foundational Knowledge of Computer Science.
References	Lecture slides plus the following textbooks:| J.v. Brocke, M. Rosemann (2010). Handbook on business process management 1 – Introduction, methods, and information Systems (International Handbooks on Information Systems), Springer| J.v. Brocke, M. Rosemann (2010). Handbook on business process management 2 – Strategic alignment, governance, people and culture (International Handbooks on Information Systems), Springer| M. Weske (2012). Business process management: concepts, languages, architectures, Springer| A. Gadatsch (2012). Geschäftsprozess-Management, Springer Vieweg.| W. van der Aalst, K. van Hee (2004). Workflow management – models, methods and systems, MIT Press| A.-W. Scheer, F. Abolhassan, W. Jost, M. Kirchmer, Eds. (2003) Business process change management, Springer
Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Thomas Rose

+ Process Management (1211902)

ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Process Management (121190202)	1st semester	no semester recommended	0	1
Exam Process Management (121190201)	1st semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Process Management	1st semester	no semester recommended	-	2

+ Learning Technologies (1215751)

Module titel	Learning Technologies (Compulsory elective subject)
Identifier	1215751
Version	V2
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2018
Valid until	-
Module level	Master
Content	Learning Technologies research and engineering is an interdisciplinary field involving competences from cognitive psychology, pedagogy, and various areas within applied computer science. The course consists of two parts: Theoretical foundations about learning and learning technologies, and practical approaches for implementing measures, tools, and techniques related to the theoretical foundations which explore new approaches and develop new learning technologies and methodologies. The theoretical foundations of the course introduces learning theories and their implications to eLearning content and system design. These learning theories are further extended with instructional design theories and multimedia learning theories about motivation and practical principles which are used as foundations for designing eLearning content and describe the eLearning design process. Further topics that are covered in the theoretical foundations include the foundations of assessment and feedback technologies as well as multimedia tools which support the various aspects of the teaching and learning processes in education. The first part of the lecture can be conveyed to the students also by using contemporary e-learning tools and techniques (which include, but not limited to: video based learning, bMOOCS, flipped classroom methodology) The practical part of the lecture takes a look at the current learning technologies and tools present in the current learning processes (but not limited to the learning context), and provides a hands-on approach on building learning technologies tools. The focus is to provide the students a possibility to gain knowledge and build practical skills for innovating and prototyping learning tools, services and systems which can be used in different educational contexts. The practical work and approaches will be connected with new learning theories and approaches which better address the new challenges which come up with the processes for digitalizing the learning environments and the new digital environments within the learning processes.. The course will introduce novel technologies for implementing innovative learning systems and components for open networked learning, and will also include techniques, methodologies and approaches which handle data, data analysis, data literacy and similar novel concepts which arise from using technology within education. The assignments take the form of practical lab courses with mandatory attendance. In the mandatory attendance sessions, the students will do hands-on exercises and receive guidelines, suggestions, and tips about designing and implementing learning tools. As an example, a typical task consists of starting with an idea about tool/component/system, and then iteratively develop it in a finished product, applying agile practical techniques, modern software engineering tools and technologies by following a (user) learner-centered approach. Students can work on these assignments alone, or in small teams.
Learning objective	Upon successful completion of this module, students are able to Knowledge: • illustrate the main aspects of current learning theories • describe a systematic process of eLearning content design • explain design principles for multimedia learning by relating them to underlying models and • theories of cognitive psychology and pedagogy • give examples of how to apply models of cognitive psychology and instructional design theories in eLearning projects • explain taxonomies of learning objectives by giving appropriate examples • give reasons and examples for eTests and automatic feedback Skills: • Analyze given designs of technology enhanced learning by applying didactic models and multimedia learning design principles • Apply didactic models and multimedia learning design principles when designing and implementing Learning Technologies • Choose and evaluate adequate tools and components for the implementation of technology enhanced learning • Develop ideas and design them as technical solutions in a learning scenario • Evaluate and assess the implementation feasibility of their ideas and designs as learning tools and technologies • Practical agile software development skills which also cover managing software projects work and deliverables • Utilize taxonomies of learning objectives when operationalizing learning objectives and designing test items • Apply principles of assessment and feedback design when implementing test sets • Should have acquired the skills to systematically plan, design and implement small to medium sized eLearning projects Competences: • Based on the knowledge and skills acquired in this module, students will be able to scientifically communicate aspects of eLearning design and eLearning research • Critically discuss learning theories

+ Learning Technologies (1215751)

	and instructional design theories in the context of requirements for learning technologies development and application • Work in interdisciplinary teams to design and implement technology enhanced learning propose creative solutions in eLearning projects • Take responsibility in project work as a reliable project partner • Identify problems in project work and come up with creative solutions
Requirements	None.
(recommended) Requirements	Participants can implement small to medium-sized projects with current development environments (usually web technologies, mobile applications, object-oriented programming), are able to quickly familiarize themselves with new development environments and tools and are motivated to learn the basic learning theories of psychology and pedagogy and didactic models.
References	-
Language	English
Grading	The module examination consists of the following partial qualifications: Project work (50 %); oral examination (50 %). Students must pass all written homework to be admitted to the examination. Attendance is mandatory in the hands-on sessions of the exercise.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr.-Ing. Ulrik Schroeder
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral)
Total hours (h)	180
Contact hours (h)	75
Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercises Learning Technologies (121575102)	no semester recommended	no semester recommended	0	2
Exam Learning Technologies (121575101)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Learning Technologies	no semester recommended	no semester recommended	-	3

+ Current Topics in Media Computing and HCI (1211908)

Module titel	Current Topics in Media Computing and HCI (Compulsory elective subject)
Identifier	1211908
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	This class covers current research trends in Human-Computer Interaction and Media Computing. We use a mix of recent book chapters and papers from conferences and journals of the last few years to give you an idea of the hot topics that are being worked on in the international research community. Examples from past years include zoomable user interfaces, haptic input/output devices, matrix calculus for user interface modelling, and ubiquitous display technologies.
Learning objective	Knowledge: On successful completion of this module, students should be able to describe how research projects in the area of Human-Computer Interaction (HCI) are established, carried out, evaluated, published, reviewed, and referenced. Furthermore, they will be able to describe findings and technologies that represent current trends in HCI research at the time. | Skills: Students learn how to survey the literature for topics in the domain of HCI, read and derive implications of HCI research publications. Additionally, they will be able to assess and discuss the value of published HCI research for academia and industrial application, and summarize and review research publications. | Competences: Based on the knowledge and skills acquired students should be able to communicate orally and in writing according to the scientific standard.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	The module examination consists of the following partial qualifications: Written Homework (15 %); Project work (10 %); “Midterm” written exam or oral examination (30 %); Written exam or oral examination (45 %).
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Jan Oliver Borchers
ECTS Credits	6
Contact time (WSH)	3
Examination duration (min)	15-45 (oral) | 90-120 (written)
Total hours (h)	180
Contact hours (h)	45
Self-study hours (h)	135

+ Current Topics in Media Computing and HCI (1211908)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Current Topics in Media Computing and HCI (121190802)	1st semester	no semester recommended	0	1
Exam Current Topics in Media Computing and HCI (121190801)	1st semester	no semester recommended	6	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Current Topics in Media Computing and HCI	1st semester	no semester recommended	-	2

RWTH AACHEN UNIVERSITY

+ eBusiness - Applications, Architecture and Standards (1212683)

Module titel	eBusiness - Applications, Architecture and Standards (Compulsory elective subject)
Identifier	1212683
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	The lecture on eBusiness addresses the impact of the digital transformation on goods, services as well as their value propositions and businesses models. As early as 1998 IBM has coined the term eBusiness as the transformation of key business processes through the use of Internet technologies. Various industries have witnessed in the meantime a magnificent transformation through digital technology implementation in products and services. Even new forms of governance have emerged on the basis of digital transformation.| The concept of block chain is for instance a technology to federate data management across a peer network at first sight. However, block chains also allow for institutional changes and new forms of regulation and control (governance) and thus represent a disruptive innovation. Rather than having one centralised institution for assuring the consistency of transactions, e.g. electronic transfer of money, a supervising organisation can be replaced by a peer-to-peer network of processing agents.| The lecture addresses first the impact of digital transformation on business process design and supporting business models. Then, enabling technologies for electronic data interchange, payment services, electronic currencies and distributed ledgers will be introduced. Scope and sources of value creation and capturing are introduced as important aspects of the ongoing digital transformation of businesses afterwards. A discussion of eCommerce portals as well as business-to-business platforms will be included as tangible ingredients in order to illustrate requirements and opportunities of digital transformation. Business modelling comes then as closing cluster point, since the design of value propositions and their implementation has proven as crucial element for any transformation.
Learning objective	Knowledge: Following this lecture, students will be in the position to identify and realize the opportunities of digital technologies and processes for businesses as well as their business models. They know basic technologies for the digitalisation of business processes in the context of electronic data interchange, online payment systems and distributed ledger technologies for new kinds of business collaboration. As further basis, they will familiarise with electronic portals for improving customer relationships as well as B2B platforms for business collaboration. Another focus are business models including their modelling and impact on governance structures.| Skills: Students can utilize digitalisation of processes and data exchange for the design of new product portfolios, can assess the impact of digital processes for the redesign eco-systems for business collaboration, integrate processes on the basis of digital infra-structure and design accompanying business models for sustainable operations.| Competencies: students can employ digitalisation for the design or re-engineering of new business opportunities, present the added value of digitalised processes and incentivise this added value in terms of business models.
Requirements	None.
(recommended) Requirements	Foundational Knowledge of Computer Science.
References	Lecture slides plus the following textbooks:| P. Beynon-Davies (2013). eBusiness, Palgrave Macmillan.| D. Chaffey (2011). E-Business and E-Commerce Management – Strategy, Implementation and Practice (5th edition), Prentice Hall| A. Meier, H. Stormer (2009). eBusiness & eCommerce – Managing the Digital Value Chain, Springer| Kane, G. C., Palmer, D., Phillips, A. N., Kiron, D., & Buckley, N. (2015). Strategy, not technology, drives digital transformation. MIT Sloan Management Review and Deloitte University| Fielt, E. (2014). Conceptualising business models: Definitions, frameworks and classifications. Journal of Business Models, 1(1).| D Chaffey (2014): Digital business and E-Commerce Management, Pearson.

+ eBusiness - Applications, Architecture and Standards (1212683)

Language	English
Grading	Written exam or oral examination (100 %). Students must pass written homework to be admitted to the module examination.
Miscellaneous	-
Module coordinator	Universitätsprofessor Dr. rer. nat. Thomas Rose
ECTS Credits	4
Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise eBusiness - Applications, Architecture and Standards (121268302)	1st semester	no semester recommended	0	1
Exam eBusiness - Applications, Architecture and Standards (121268301)	1st semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture eBusiness - Applications, Architecture and Standards	1st semester	no semester recommended	-	2

+ Social Data Science (7016925)

Module titel	Social Data Science (Compulsory elective subject)
Identifier	7016925
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Summer semester 2018
Valid until	-
Module level	Bachelor/Master
Content	This module teaches key methods for analyzing social data, featuring foundations of data modelling and algorithmic modelling, discrimination-aware machine learning, collective dynamics, time series modelling, causal inference, experiment design and natural experiments, simulation (e.g., Conway's game of life, Ising model, Schelling's segregation model, ...), and applications such as the analysis of biases, polarization, and culture with data.
Learning objective	Knowledge: On successful completion of this module, students should have acquired an overview of topics and methods for analyzing social data. They should have understood key approaches and methods to identify community structures in networks, to analyze time series data, to infer (probable) causal relationships from data, and to perform simulations in depth. Students should also know about tools to apply the learned methods in practice. | Skills: After this course, students should be able to apply their knowledge to propose and execute adequate solutions for answering research question with social data. | Competences: Students should establish critical thinking regarding assumptions and possibilities of social network analysis.
Requirements	-
(recommended) Requirements	Basic programming skills as taught in 'Programmierkurs (Java)' and "Scientific Programming in Python', basic knowledge about statistics and knowledge from lectures 'Datenstrukturen und Algorithmen' and 'Datenbanken und Informationssysteme' or equivalent. Knowledge from lecture "Machine Learning" is recommended.
References	R. Alvarez: "Computational Social Science: Discovery and Prediction", 2016
Language	English
Grading	The grading results from the final exam of this module. The exam can be a written or an oral exam. The final form of the examination is announced at the beginning of the lecture. Homework may count towards the final examination grade. The exam is done at the end of the lecture period.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation: LeMa-Team Philosophische Fakultät, modulangebotsorganisation@fb7.rwth-aachen.de ;Modulverantwortlicher: Univ.-Prof. Dr. techn. Markus Strohmaier ;
ECTS Credits	6
Contact time (WSH)	5
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	180
Contact hours (h)	75

+ Social Data Science (7016925)

Self-study hours (h)	105

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam Social Data Science (701692501)	1st semester	no semester recommended	6	0
Exercise Social Data Science (701692502)	1st semester	no semester recommended	0	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Social Data Science	1st semester	no semester recommended	-	3

+ Data Driven Medicine - project-oriented, multidisciplinary ...

Module titel	Data Driven Medicine - project-oriented, multidisciplinary introduction (Compulsory elective subject)
Identifier	1215842
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2018
Valid until	-
Module level	Master
Content	Data play an important role in medicine: Intensive care relies on monitors presenting and analysing real-time patient data, medical imaging has become a domain of massive data processing, diagnostics rely on laboratory data, and the importance of data is ever increasing: Wearable sensors, mobile communication devices and respective apps will produce data streams, which support preventive measures in healthy individuals or allow screening as a basis for data-based prevention of diseases. Last but not least: molecular biology (e.g. by gene sequencing and gene expression analysis) introduces new biomarkers, which enable new minimally-invasive diagnostics and approaches to tailoring treatments based on individual characteristics of patients (precision medicine) – which would never be possible without sophisticated processing of huge amounts of data. Medical decision making in general will be markedly influenced by data processing and data analytics. Thus, we can expect data driven medicine to gain momentum in the nearer future. This course offers a project-oriented, multidisciplinary introduction to the basics of data driven medicine. Orientation, fundamental concepts, and methodological approaches are provided by lectures. In addition, the participants will also form small interdisciplinary teams including students of computer science as well as medical students in order to plan and implement an own project, which targets prediction or decision support generated from medical data.
Learning objective	Knowledge: After the course the participants should be able to 1) describe the role of natural language in medical documentation, 2) name and describe relevant methods of predictive analytics and machine learning, 3) name and describe methods for dimensionality reduction, 4) locate data sources for medical big data. | Skills: The participants should be able 1) to extract, load, transform data from relevant medical data sources of medical data via application programming interfaces, 2) access and use medical terminology servers, 3) transform given medical data to standardized representation formats (RDF triplets, i2b2-star-schema), 4) access, design, provide and use medical metadata repositories and ontologies, 5) apply and validate basic machine learning algorithms to medical data | Competences: The participants will acquire the competence to 1) assess data quality of medical data sources, 2) adopt basic methods of natural language processing for providing semantic enrichment and text mining , 3) adopt basic methods of bad data curation, 4) use data to predict important outcomes (predictive modelling)
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	The module examination consists of the following partial qualifications: Project work and Presentation (60 %); Written Exam (40 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Dr. rer. nat. Cord Spreckelsen & Universitätsprofessor Dr. rer. pol. Stefan Decker & Oya Deniz Beyan Ph. D.
ECTS Credits	4

+ Data Driven Medicine - project-oriented, multidisciplinary ...

Contact time (WSH)	3
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	45
Self-study hours (h)	75

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exercise Data Driven Medicine - project-oriented, multidisciplinary introduction (121584202)	1st semester	no semester recommended	0	1
Exam Data Driven Medicine - project-oriented, multidisciplinary introduction (121584201)	1st semester	no semester recommended	4	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture Data Driven Medicine - project-oriented, multidisciplinary introduction	1st semester	no semester recommended	-	2

+ Language, Culture, and Cognition (KP20890)

Module titel	Language, Culture, and Cognition (Compulsory elective subject)
Identifier	KP20890
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Summer semester 2019
Valid until	-
Module level	Master
Content	This class provides a broad overview of linguistic relativity, the notion that there is a causal connection between the form of one's language and the content of one's thought. Lectures will first introduce a contrast between languages and then explore evidence of psychological differences between users. Specific topics include color terminology, prepositional phrases, bilingualism, numerical cognition, homesign and sign language.
Learning objective	Knowledge: Descriptive linguistics, experimental psychology and linguistic anthropology pertaining to linguistic relativity. Topics including categorical perception, navigation, modality, etc. Skills: Academic reading/writing in the above domains. Competences: Scientific literacy and oral debate on relevant evidence. Synthesis of academic publications and/or rudimentary data analysis.
Requirements	None.
(recommended) Requirements	None.
References	Lucy, J. A. (1992). Language diversity and thought: A reformulation of the linguistic relativity hypothesis (Vol. 12). Cambridge University Press.
Language	English
Grading	The module examination consists of the following partial qualifications: Written exam or oral examination (60 %); Written homework (40 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	Universitätsprofessorin Irene Mittelberg, Ph.D.
ECTS Credits	4
Contact time (WSH)	4
Examination duration (min)	15-30 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

+ Language, Culture, and Cognition (KP20890)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Language, Culture, and Cognition (Exam) (KP2089001)	1st semester	1st semester	4	0

Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Language, Culture, and Cognition (Lecture)	1st semester	1st semester	-	3

+ Language, Mind, and Media (KP20930)

Module titel	Language, Mind, and Media (Compulsory elective subject)
Identifier	KP20930
Version	-
Duration (Semester)	one semester
Cycle (Semester)	irregularly
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	This seminar focuses on two central dimensions of human cognitive capacity, that is, language and mind. The third aspect, media, will be examined in order to understand the interrelation between language and mind in daily practices and routines. As a vivid example, spatial orientation in real or virtual spaces will be at the center of this seminar, though not exclusively. Human beings move in real or virtual spaces on a daily basis and practice, they consciously talk about space, use spatial metaphors, and represent these different knowledge systems as mental models. As such, human beings apply different cultural practices using different encoding systems, e.g., structuring the virtual space of an egoshooter computer game by applying different strategies to orient oneself in a house, hallway, or room. Linguistically, people in different languages, different cultures and different surroundings use various encoding devices to relate (spatial) information. Language as one key encoding system thus plays a crucial role in the instantiation of spatial relations, but language is only one part of the spatial story. This seminar investigates, among other aspects, linguistic and cognitive structures based on mental images and environmental input coming from visual arts, virtual and augmented realities and computer game studies. We will survey the idea that the parallels between language, mind (cognition) and media indicate a bridging element between those different levels of human conceptual organization. Main questions are: a) How do different media affect and maybe even alter language and cognition and vice versa? b) What impact have different routines, e.g., using GIS systems on smartphone applications, computer games and other devices, on our (visual) perception? c) What structuring effects do we find from language upon the human mind? d) And following this question, are language and mind two separated spheres?
Learning objective	-
Requirements	None.
(recommended) Requirements	None.
References	Emmorey, K. (2001). Language, cognition, and the brain: Insights from sign language research. Psychology Press.
Language	English
Grading	The module examination consists of the following partial qualifications: Project work (50 %); Colloquium (50 %).
Miscellaneous	-
Module coordinator	Universitätsprofessorin Irene Mittelberg, Ph.D.
ECTS Credits	4
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral)

+ Language, Mind, and Media (KP20930)

Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Language, Mind, and Me-dia (Exam) (KP2093001)	1st semester	no semester recommended	4	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Language, Mind, and Me-dia (Lecture)	1st semester	no semester recommended	-	4

RWTH AACHEN UNIVERSITY

+ Practical Lab Fraunhofer (KP20937)

Module titel	Practical Lab Fraunhofer (Compulsory elective subject)
Identifier	KP20937
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Students should independently apply subject-specific knowledge and methods of conception, implementation and testing of software and hardware systems as well as of experiments and measurements. Usually, a task is carried out in small groups in order to train the ability of the students to work in a team. This practical lab is offered by one of the cooperating Fraunhofer Institutes FIT or IAIS and therefore focuses on the respective research foci and project work.
Learning objective	Knowledge: On successful completion of this module, students should be able to state the advantages and disadvantages of various methods used for solving problems for the given application domain. | Skills: They should be able to brainstorm and filter ideas and iteratively develop an application on a given topic. | Competences: Based on the knowledge and skills acquired they should be able to communicate orally, work in teams, plan projects and meet milestones.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Practical training (100 %). Attendance in the practical lab is mandatory.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation b-it
ECTS Credits	10
Contact time (WSH)	5
Examination duration (min)	-
Total hours (h)	300
Contact hours (h)	75
Self-study hours (h)	225

+ Practical Lab Fraunhofer (KP20937)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Practical Lab Fraunhofer (KP2093701)	1st semester	no semester recommended	10	5

RWTH AACHEN UNIVERSITY

+ Practical Lab (KP21164)

Module titel	Practical Lab (Compulsory elective subject)
Identifier	KP21164
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	Students should independently apply subject-specific knowledge and methods of conception, implementation and testing of software and hardware systems as well as of experiments and measurements. Usually, a task is carried out in small groups in order to train the ability of the students to work in a team.
Learning objective	Knowledge: On successful completion of this module, students should be able to state the advantages and disadvantages of various methods used for solving problems for the given application domain. | Skills: They should be able to brainstorm and filter ideas and iteratively develop an application on a given topic. | Competences: Based on the knowledge and skills acquired they should be able to communicate orally, work in teams, plan projects and meet milestones.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Practical training (100 %). Attendance in the practical lab is mandatory.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation b-it
ECTS Credits	9
Contact time (WSH)	5
Examination duration (min)	-
Total hours (h)	270
Contact hours (h)	75
Self-study hours (h)	195

+ Practical Lab (KP21164)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Practical Lab (KP2116401)	1st semester	no semester recommended	9	5

RWTH AACHEN UNIVERSITY

+ Software Lab (1215759)

Module titel	Software Lab (Compulsory elective subject)
Identifier	1215759
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2020
Valid until	-
Module level	Master
Content	In the practical lab, the students should independently apply subject-specific knowledge and methods in the conception, implementation and testing of software and hardware systems as well as in the execution of experiments and measurements. Usually, a task is carried out in small groups.
Learning objective	Knowledge: On successful completion of this module, students should be able to state the advantages and disadvantages of various methods used for solving problems for the given application domain. | Skills: They should be able to brainstorm and filter ideas and iteratively develop applications on a given topic. | Competences: Based on the knowledge and skills acquired they should be able to communicate orally, work in teams, plan projects and meet milestones.
Requirements	-
(recommended) Requirements	None.
References	-
Language	English
Grading	Practical training (100 %). Attendance in the practical lab is mandatory.
Miscellaneous	-
Module coordinator	Fachgruppe Informatik
ECTS Credits	7
Contact time (WSH)	-
Examination duration (min)	-
Total hours (h)	210
Contact hours (h)	-
Self-study hours (h)	-

+ Software Lab (1215759)

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lab Course (121575901)	no semester recommended	no semester recommended	7	0

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lab Course	no semester recommended	no semester recommended	-	4

+ Technical Writing (KP20932)

Module titel	Technical Writing (Compulsory elective subject)
Identifier	KP20932
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	The thematic steps of course are as follows: (1) Text type-theory; achieving text type knowledge, (2) Preliminary stages of scientific/technical Writing, (3) Conditions of writing to achieve specific aims of action, (4) Retrieving and structuring materials: argumentation structure and organisation of texts, (5) Process of writing.
Learning objective	Knowledge: The main goal of this module is to give students an introduction to the theory and practise of writing in academic and technical contexts. Therefore, they will be given an understanding of writing as a creative process. Knowing how to write (organising and structuring texts, building an argumentation, convincing through arguments, making the text intention comprehensible etc.) is a main competence in business and the scientific world. Students should be able to differentiate between technical and scientific text types and to find suitable strategies for writing different kinds of texts. On successful completion of this course, students should be able to address specific target groups, achieve textual comprehensibility and write e.g. argumentative, causal analytical or problem solving texts. | Skills: The focus of this course is to work on the students' ability to communicate with texts. Considering the characteristics of different text types in the field of academic and technical writing, students should be able to identify the functions of a text, its structure and its formal aspects. By applying these skills accordingly to their own texts, they should able to write convincing, structured and comprehensible texts themselves. | Competences: Based on the knowledge and skills acquired in this course, students will learn the following key competences when it comes to writing academic papers and technical documentations: Students will learn to organise the writing process itself (time-management), to structure their (research) material and, also, to build an argumentative, coherent and comprehensible text. Moreover, they will learn to apply methodical standards in technical and academic writing, e.g. proper referencing, in order to stabilize their personal and scientific integrity. Furthermore, students will apply the so called 'text-feedback-method', which allows them to give feedback on and discuss texts written by their colleagues. Afterwards, they should be able to adequately criticise others and learn to be criticised for their own texts. With respect to social competences, students will learn to work together in groups and to cope with writing problems. In this group-work, they will learn to identify problems, find and argue for appropriate solutions and present their results to their fellow students.
Requirements	None.
(recommended) Requirements	None.
References	-
Language	English
Grading	Written Exam (100 %). Students must pass written homework to be admitted to the examination.
Miscellaneous	-
Module coordinator	PD Alexander Keus
ECTS Credits	4

+ Technical Writing (KP20932)

Contact time (WSH)	4
Examination duration (min)	60-90 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Technical Writing (Exam) (KP2093201)	1st semester	no semester recommended	4	-

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Technical Writing (Lecture)	1st semester	no semester recommended	-	4

+ Seminar Computer Science (1211974)

Module titel	Seminar Computer Science (Compulsory elective subject)
Identifier	1211974
Version	Angelegt über RWTH API als 1_neu
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Summer semester 2020
Valid until	-
Module level	Bachelor
Content	The educational objective here is reached by practice on personally assigned specialized topics from computer science, as well as active participation in the presentation meetings. The areas of the topics to be assigned are chosen by the respective instructor offering the proseminar.
Learning objective	Acquisition of the following knowledge and skills to be able to treat and present concepts, methods, and results of a scientific topic from computer science appropriately: Ability to treat a specialized topic from computer science independently on the basis of appropriate references, especially scientific original articles, to classify the topic appropriately, to narrow the topic down, and to develop a critical evaluation. Ability to create a comprehensive written report on a given special topic from computer science with clarity and reasonable formalisms, within a given time frame and of a defined length; proof of independent development by presentation of appropriate self-selected examples. Ability plan and carry out a vivid oral presentation of a specialized topic from computer science using appropriate media and examples within a given time frame. Ability to participate actively in discussions on special topics of computer science in courses with compulsory attendance.
Requirements	-
(recommended) Requirements	None.
References	Topic-dependent; is specified or researched by the student.
Language	German
Grading	Written homework and presentation (100 %). Attendance in the seminar is mandatory.
Miscellaneous	-
Module coordinator	Fachgruppe Informatik
ECTS Credits	4
Contact time (WSH)	2
Examination duration (min)	-
Total hours (h)	120
Contact hours (h)	30
Self-study hours (h)	90

+ Seminar Computer Science (1211974)

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Seminar (121197401)	no semester recommended	no semester recommended	4	2

RWTH AACHEN UNIVERSITY

– German Language Course or Additional ...
+ German Language Course (1215734)

Module titel	German Language Course (Compulsory elective subject)
Identifier	1215734
Version	Angelegt über RWTH API als 1
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2001
Valid until	-
Module level	Master
Content	German courses enable students to acquire basic German language skills or to broaden and deepen existing skills based on the level of their previous knowledge. Topics range from interpersonal communication and aspects of everyday life to encounters with Germany and Europe to an exploration of cultural differences. Depending on course level, specifics of the German university system and subjects relating to students' study programs will also be treated. Grammatical structures are learned in the context of these topics via concrete speaking activities corresponding to appropriate communicative tasks. The acquisition of vocabulary is achieved through an active vocabulary transfer in varying contexts and different exercise forms.
Learning objective	At the end of the course students will be able to accomplish a variety of level-specific communicative tasks relevant to their academic context and university environment. In addition, students will gain an insight into German and European culture and develop appropriate intercultural competences.
Requirements	None.
(recommended) Requirements	None.
References	Students will be instructed as to which course book they must acquire. Additional course material will be provided in the form of handouts or will be uploaded to the course learning platform.
Language	German
Grading	Students are required to attend regularly and to pass two course tests. Grades will be accorded on the basis of "midterm" written exam or oral examination and a final written exam or oral examination. Attendance in the language course is mandatory.
Miscellaneous	-
Module coordinator	Sprachenzentrum
ECTS Credits	4
Contact time (WSH)	4
Examination duration (min)	15-45 (mündlich/oral) | 90-120 (schriftlich/written)
Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

● Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Exam German Language Course (121573401)	1st semester	no semester recommended	4	2

▲ Offer node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Lecture/Exercise German Language Course	1st semester	no semester recommended	-	4

RWTH AACHEN UNIVERSITY

– German Language Course or Additional ...
+ Additional Seminar (KP20938)

Module titel	Additional Seminar (Compulsory elective subject)
Identifier	KP20938
Version	-
Duration (Semester)	one semester
Cycle (Semester)	winter/summer semester
Valid from	Winter semester 2019
Valid until	-
Module level	Master
Content	The achievement of the learning objectives is pursued by practice on the basis of personally assigned in-depth scientific topics as well as active participation in the presentation dates. The choice of topics is the responsibility of the respective organizer.
Learning objective	Knowledge: Upon successful completion of the module, students should be able to identify current research problems and describe the state of the art. | Skills: You should be able to distinguish between relevant and irrelevant material, to search the relevant literature, to present what you have learned in a visually appealing way, and to present what you have learned to a broad audience in an understandable way. | Competences: Based on their knowledge and skills, students should be able to understand scientific publications, critically evaluate research results, and give a scientific presentation.
Requirements	None.
(recommended) Requirements	None.
References	Topic-dependent; is specified or researched by the student
Language	English
Grading	Written homework and presentation (100 %). Attendance in the seminar is mandatory.
Miscellaneous	-
Module coordinator	Modulangebotsorganisation b-it
ECTS Credits	4
Contact time (WSH)	4
Examination duration (min)	-
Total hours (h)	120
Contact hours (h)	60
Self-study hours (h)	60

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Additional Seminar (KP2093801)	no semester recommended	no semester recommended	4	4

+ Master thesis

Module titel	Master thesis (Compulsory subject)
Identifier	-
Version	-
Duration (Semester)	-
Cycle (Semester)	-
Valid from	-
Valid until	-
Module level	-
Content	-
Learning objective	-
Requirements	-
(recommended) Requirements	-
References	-
Language	-
Grading	-
Miscellaneous	-
Module coordinator	-
ECTS Credits	30
Contact time (WSH)	-
Examination duration (min)	-
Total hours (h)	900
Contact hours (h)	-
Self-study hours (h)	-

Exam node

Title	Recommended Semester (Study start winter)	Recommended Semester (Study start summer)	ECTS Credits	Contact time (WSH)
Master thesis	no semester recommended	no semester recommended	30	-