

## Module Handbook Department of Informatics 2024 English

Draft – English translation – not legally binding

Program

Master of Science Intelligent Adaptive Systems

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# **General information**

### Content of a module description

Module title	The title of the module					
Module number/code	The number/code for the module (e.g., InfB, Inf	M, or IT/	MC-XXX)			
Module applicability, type and	Examples:					
curricular area	Master of Science in Informatics: Required Elective					
	Master of Science in Data Science and Artificial Intelligence: Required					
Prerequisites	Mandatory: other modules that must be compl	Mandatory: other modules that must be completed before commencement, i.e., passing				
	the respective examinations. "None" means that	at there a	are not any i	mandatory		
	prerequisites.					
	Recommended: prerequisites for which proof o	f comple	tion does no	ot necessaril	y need to	
	be submitted before starting the module. "Non	e" mear	is that there	are not any		
	recommended prerequisites.					
Module coordinator(s)	Generally a professor					
Teaching staff	Generally the module coordinator, plus further	teaching	g staff where	relevant.		
Language	Examples:					
	German with teaching materials in German and	l English	ı; English wi <sup>.</sup>	th teaching	materials	
	in English.	U	C	C		
	Master's modules can be taught in German and	teachin	g materials	provided in	German	
	and/or English. It must be possible to complete	a bache	lor's degree	programs in	German,	
	that is, required modules and sufficient required	d electiv	e modules n	nust be offer	ed in	
	German for each degree program.					
Qualifikationsziele	Guiding question for a skills-based description of	of the Q	ualification t	argets: whi	ch	
	Qualification targets will students have achieve	d upon s	successful co	mpletion of	fthe	
	module?	•				
	Examples: Students are able to design and valid	late syst	ems and are	familiar wi	th a	
	modeling method. Through practical work, they	/ have fu	irthered thei	ir ability to g	grasp	
	specific types of problems and select appropriat	e soluti	ons			
Contents	Guiding question on the content: Which specia	list, met	hodological,	practical, a	nd	
	interdisciplinary content will be taught to ensur	e the m	odule object	ives are met	t?	
Course components and	Example: Lecture Course 1 (2 credit hours per we	eek)				
teaching format(s)	Example: Exercises Course 2 (2 credit hours per	week)				
Workload	· · · · · · · · · · · · · · · · · · ·	Credit	s P (hrs)	S (hrs)	EP (hrs)	
(course components and	Lecture Course 1	3	28	42	20	
overall)	Exercises Course 2	3	28	42	20	
	Summe	6	56	84	40	
	Breakdown of the workload in hours (30 hours p	er ECTS	credit) into	attendance	•	
	hours (P), independent study (S) and examination	on prepa	ration (EP).	As a rule,		
	the number of attendance hours is equal to the	number	r of credit ho	ours per		
	week multiplied by 14 weeks.					
Academic requirements and	Examples:					
examinations	Academic requirements: Regular and successfu	l particip	pation in the	seminar / p	oractical	
	course. Participation in the seminar is deemed	to have l	peen success	ful if the to	pic has	
	been understood, appropriately addressed in a	presenta	ition, and ex	plored in wi	iting.	
	Participation in the practical course is deemed t	o have b	een success	ful if all assi	gnments	
	have been completed and at least 50 % have bee	en solve	d correctly. A	Any changes	to these	
	criteria must be announced prior to module reg	istratior	ı.			
	Examples:					
	Examinations: Joint examination for all module	courses	; generally a	in oral exam	ination in	
	the teaching language. Alternatively, a written	examina	ition is possi	ble. The exa	mination	
	type(s) will be announced prior to module regis	tration.				
	Grades will be awarded for the examinations in	this mo	dule.			
Module duration	One semester					
Semester(s) offered	Semester(s) in which the course is offered.					
Literature						

#### Key

Credits = ECTS credits P (hrs) = attendance (hours) S (hrs) = independent study (hours) EP (hrs) = examination preparation (hours)

MIN-PO = Prüfungsordnung B.Sc. bzw. M.Sc. der MIN-Fakultät der Universität Hamburg

FSBs = subject-specific provisions for the degree program

# **1** Modules of Teaching Unit Informatics

Module title	Bio-Inspired Artificia Intelligence					
Module number/code	InfM-BAI					
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Data Science	M.Sc. Informatics: Advanced modules / Focus Data Science: Selection				
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced T	opics in D	ata Scienc	e and Artif	ficial	
	Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics					
	M.Sc. Bioinformatics: Required elective area – informatics	M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences,				
	informatics, and bioinformatics					
	M.Sc. Intelligent Adaptive Systems: Required modules					
Prerequisites	Mandatory: none					
	Recommended: none					
Module coordinator(s)	Wermter					
Teaching staff	Wermter, N.N.					
Language	English with teaching materials in English					
Qualification targets	Students are familiar with the scientific investigation and	l use of in	telligent b	ehavior in	nature: They	
	are acquainted with the principles of biological intelligen	t strategie	es. Studen	ts are able	to critically	
	analyze relevant characteristics and can implement these	characte	ristics in co	omputer n	nodels for	
	intelligent systems and robots.			•		
Contents	Students are introduced to interdisciplinary research thro	ugh an ex	ploration	of the met	hods of	
	artificial intelligence based on biological or human capab	ilities. In f	he semina	ar, models	from the	
	latest research are evaluated and linked to the material co	overed in <sup>.</sup>	the lecture	e. The char	nging topics	
	explored during the seminar are determined before the st	tart of the	academic	: year to ta	ke into	
	account changing demands and current research directions.					
	The content focuses on advanced methods for bio-inspire	d AI syste	ms:			
	<ul> <li>cellular systems and spiking neural systems</li> </ul>					
	<ul> <li>bio-inspired image and language processing</li> </ul>					
	<ul> <li>evolutionary systems and bio-inspired robots</li> </ul>					
	<ul> <li>communication-based cooperation and human-rol</li> </ul>	pot intera	ction			
Course components and teaching	Lecture Bio-Inspired Artificial Intelligence (2 credit hours r	per week)				
format(s)	Seminar Bio-Inspired Artificial Intelligence (2 credit hours	per week	)			
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)	
(course components and overall)	Lecture Bio-Inspired Artificial Intelligence	3	28	42	20	
	Seminar Bio-Inspired Artificial Intelligence	3	28	42	20	
	Total workload	6	56	84	40	
Academic requirements and	Coursework: Regular and successful participation in the s	eminar. P	articipatic	n in a sem	inar is	
examinations	essentially deemed to have been successful if the respect	ive topic a	ireas have	been unde	erstood,	
	adequately presented and, if applicable, also adequately	explored i	n a writtei	n paper. Ai	ny changes to	
	the criteria must be announced prior to module registrati	on.			, ,	
	Exam(s): Joint examination for all module courses; genera	ally, an ora	al examina	tion in the	e teaching	
	language. Alternatively, a written examination is possible	e. The exa	mination t	ype(s) will	be	
	announced prior to module registration.					
	Grades will be awarded for the module examination(s).					
Module duration	1 semester					
Semester(s) offered	Winter semester, every year					
Literature	Floreano, D., Mattiussi, C., Bio-inspired Artificial Intelligen	ce: Theor	ies, Metho	ds, and Te	chnologies.	
	MIT Press, 2008.				-	
	Eberhart, R.C., Shi, Y., Computational Intelligence: Concep	ts to Impl	ementatio	ons. Elsevie	er/Morgan	
	Kaufmann, 2007.	·			-	

Module title	Computer Vision I						
Module number/code	InfM-CV1						
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection						
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial						
	A Sc. Picieformatics Paquired elective areainformatics und Paquired elective arealife sciences						
	A.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences,						
	informatics, and bioinformatics						
	M.Sc. Intelligent Adaptive Systems: Required elective area	a					
Prerequisites	Mandatory: none						
	Recommended: none						
Module coordinator(s)	Frintrop						
Teaching staff	Frintrop, N.N.						
Language	English with teaching materials in English						
Qualification targets	Students know the basics of digital image processing and	l compute	er vision, r	einforced	through		
	exercises.						
Contents	Focus areas: fundamentals of image processing (digital fi	Focus areas: fundamentals of image processing (digital filters, smoothing, and edge detection),					
	feature extraction (DOG, SIFT, and HOG) and object recog	nition wi	th feature	s, image se	egmentation,		
	and superpixel methods, and object classification using r	nachine le	earning an	id especial	ly deep		
	learning.						
Course components and teaching	Lecture Computer Vision I (2 credit hours per week)						
format(s)	Exercises Computer Vision I (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Computer Vision I	3	28	42	20		
	Exercises Computer Vision I	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the s	eminar/e	xercises. I	Participati	on in the		
examinations	seminar is deemed to have been successful if the topic ha	as been ur	nderstood	, appropria	ately		
	addressed in a presentation, and explored in writing. Part	ticipation	in the exe	rcises is de	eemed to have		
	been successful if all assignments have been completed a	and at lea	st 50 % ha	ve been so	lved correctly.		
	Any changes to these criteria must be announced prior to	module	registratio	on.			
	Exam(s): Joint examination for all module courses; gener	ally, a wri	tten exam	ination in	the teaching		
	language. Alternatively, an oral examination may be poss	ible. The	examinat	ion type(s)	will be		
	announced prior to module registration.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Winter semester, every year						
Literature							

Module title	Computer Vision II						
Module number/code	InfM-CV 2						
Module applicability, type and	M.Sc. Informatics: Advanced modules						
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial						
	ntelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics						
	M.Sc. Intelligent Adaptive Systems: Required elective are	a					
Prerequisites	Mandatory: none	Mandatory: none					
	Recommended: InfM-CV1	ecommended: InfM-CV1					
Module coordinator(s)	Frintrop						
Teaching staff	Frintrop, N.N.						
Language	English with teaching materials in English						
Qualification targets	Students possess in-depth knowledge of current research	i topics re	garding in	nage proce	essing and are		
	able to independently apply this knowledge to their indiv	vidual rese	earch in th	is area.			
Contents	Specific current research topics in image processing are se	elected fo	r detailed	discussion	n. Topics may		
	include the following: visual attention, saliency detection	n, object d	liscovery, a	active visio	on, and		
	convolutional neural networks.						
Course components and teaching	Lecture Computer Vision II (2 credit hours per week)						
format(s)	Exercises/Seminar Computer Vision II (2 credit hours per	week)					
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Computer Vision II	3	28	42	20		
	Exercises/Seminar Computer Vision II	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the s	eminar/e	exercises. I	Participati	on in the		
examinations	seminar is deemed to have been successful if the topic ha	as been ui	nderstood	, appropria	ately		
	addressed in a presentation, and explored in writing. Part	ticipation	in the exe	rcises is d	eemed to have		
	been successful if all assignments have been completed a	and at lea	st 50 % ha	ve been so	olved correctly.		
	Any changes to these criteria must be announced prior to	module	registratio	on.			
	Exam(s): Joint examination for all module courses; gener	ally, an or	al examin	ation in th	ie teaching		
	language. Alternatively, a written examination is possible	e. The exa	mination	type(s) wi	ll be		
	announced prior to module registration.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Summer semester, at least every other year						
Literature							

Module number/code         InfM-DIS           Module applicability, type and curricular area         M.S.E. Informatics: Required elective area – general / Focus Data Science: At Lesst two out of InfM-DIS, InfM-ML, InfM-STSP           M.S.C. Data Science and Artificial Intelligence: Required elective area – If undamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics           M.S.C. Dia Science and Artificial Intelligence: Required elective area – If development and Management of Information Systems: Required elective area – Informatics und Specialization – Development and Management of Systems: Required elective area – Informatics und Required elective area – Informatics, and bioinformatics M.S.C. Intelligent Adaptive Systems: Required elective area           Prerequisites         Mandatory: none           Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL) basic knowledge of semi-structured data management (XML, XML Schema, XML query language); basic knowledge of semi-structured data management (XML, XML Schema, XML query language); basic knowledge of the basic principles, concepts, and methods of data management, data preparatia, in English           Qualification targets         Students have in-depth knowledge of the basic principles, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and ack knowledge assets and to conceptualize and implement database management systems, especially transaction integrating databases solution corumstanaes. They are moreover aware of the possibilities for integrating databases so	Module title	Databases and Information Systems						
Module applicability, type and curricular area       M.Sc. Informatics: Required elective area - general / Focus Data Science: At least two out of InfM-DIS, InfM-ML, InfM-STSP         M.Sc. Data Science and Artificial Intelligence: and Domain Knowledge in Data Science and Artificial Intelligence: Informatics       M.Sc. Data Science and Artificial Intelligence: Informatics und Specialization - Development and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics         M.Sc. Information Systems: Required elective area - Informatics und Specialization - Development and Management of Informatics Required elective area - Informatics und Specialization - Development and Management of Informatics         M.Sc. Information: Systems: Required elective area - Informatics und Required elective area - Informatics, and bioinformatics         M.Sc. Information: Systems: Required elective area - Informatics und Required elective area - Informatics, and bioinformatics         M.Sc. Information: Systems: Required elective area         M.Sc. Informatics: South Systems: Required elective area         Module coordinator(s)       Professur Data Engineering         Traching staff       Professur Data Engineering         Qualification targets       Students have in-depth knowledge of the basic principle, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and extensibility of integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).         Conte	Module number/code	InfM-DIS						
curricular area       InfM-DIS, InfM-ML, InfM-STSP         MSc, Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence: Informatics         MSc, Data Science and Artificial Intelligence: Required elective area – IT development         MSc, Data Science and Artificial Intelligence: Informatics         MSc, Diformation Systems: Required elective area – Informatics und Specialization – Development and Management of Informatics, and bioinformatics         MSc, Distributed informatics         Module coordinator(s)         Professur Data Engineering         Teaching staff         Professur Data Engineering         Qualification targets         Students have in-depth knowledge of the basic principles, concepts, and methods of data management, distribute and information systems and adapt data base systems to specific application circumstances. They are moreover aware of the possibilities for integrafing database solutions into complex software systems and advective database systems and advective database systems to specific application systems.         Coule components and teaching       Language database and information systems.         Coule contes       Students explore current database te	Module applicability, type and	N.Sc. Informatics: Required elective area – general / Focus Data Science: At least two out of						
M.Sc. Data Science and Artificial Intelligence: Required elective area – fundamentals of Data Science and Artificial Intelligence: Informatics       M.Sc. Difficial Intelligence: Index Science and Artificial Intelligence: Informatics         M.Sc. Difficial Intelligence: Required elective area – Informatics und Specialization – Development and Management of Information Systems: M.Sc. Bioinformatics: Required elective area – Informatics und Required elective area – Informatics, informatics, and bioinformatics: Required elective area – Informatics und Required elective area – Informatics M.Sc. Intelligent Adaptive Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems: Required elective area – Informatics und Required elective area – Informatics, M.Sc. Ditability Systems, Data Signer and Required elective area – Informatics, M.G. Difference, Systems, S.S. Students have in-depth knowledge of the basic principles, concepts, and rectinal database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex softwares systems, Idata warehouses or web-based distributed information systems, Stems in database and information systems, Focus areas: curenet database technology, object-relational database sy	curricular area	nfM-DIS, InfM-ML, InfM-STSP						
and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence:       Informatics         M.Sc. IT Management and Consulting: Required elective area – Informatics und Specialization – Development       M.Sc. Information Systems: Required elective area – Informatics und Specialization – Development and Management of Information Systems: Required elective area – Informatics und Specialization – Development         M.Sc. Dicelligent Adaptive Systems: Required elective area – Informatics und Required elective area – Informatics und Required elective area – Informatics und Specialization – Development         M.Sc. Dicelligent Adaptive Systems: Required elective area       Peresuistes         Meandary: nore       Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL): basic knowledge of semi-structured data management (XML, XML schema, XML query language); basic knowledge of semi-structured data management (ML, XML schema, XML query language); basic knowledge of the basic principles, concepts, and methods of data         Module coordinator(s)       Professur Data Engineering       Unalification targets         Students have in-depth knowledge of the basic principles, concepts, and methods of data       ansate and to conceptualize and innipment database and information systems and adapt database systems to bandle data and knowledge assets and to conceptualize and innipment database and information systems, encure at alabase technology; object-relational database sortew-based distributed, and Internet-based information systems.         Contents       Students explore current database echnology; object-relational database management systems; edica		M.Sc. Data Science and Artificial Intelligence: Required el	M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science					
Informatics       M.Sc. Information Systems: Required elective area – Informatics und Specialization – Development and Management of Information Systems         M.Sc. Informatics: Required elective area – Informatics und Required elective area – life sciences, informatics, and bioinformatics       M.Sc. Bioinformatics: Required elective area – Informatics und Required elective area – life sciences, M.Sc. Intelligent Adaptive Systems: Required elective area         Prerequisites       Mandatory: none       Mandatory: none         Recommended: In depth knowledge of the relational database model (ER modeling, normalization, NML query language); basic knowledge of semi-structured data management (XML, XML schema, XML query language); basic knowledge of the relational algebra, SQL); basic knowledge of the relational digebra science and the science of the possibilities for integrating and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement data bases end information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).         Contents       Students explore current approaches to the design and implementation of centralized, distributed, and internet-based information systems (atabase explore); database esplore); database especially transaction management, distributed data management and web access; data warehouses or web-based distributed information systems (a tabase esplore); database esplore);		and Artificial Intelligence und Domain Knowledge in Data	Science a	and Artific	ial Intellig	ence:		
M.Sc. IT Management and Consulting: Required elective area – Informatics und Specialization – Development and Management of Informatics Systems: Required elective area – Informatics und Required elective area –		Informatics						
M.Sc. Information Systems:       Required elective area – Informatics und Specialization – Development and Management of Information Systems         M.Sc. Bioinformatics:       Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics         M.Sc. Intelligent Adaptive Systems:       Required elective area         Prerequisites       Mandatory: none         Recommended:       Indepth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL); basic knowledge of formal logic (Horn clause logic, predicate calculus)         Module coordinator(s)       Professur Data Engineering, N.N.         Language       English with teaching materials in English         Qualification targets       Students have in-depth knowledge of the basic principles, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems of adaptication systems and to complex software systems (data warehouses or web-based distributed information systems).         Contents       Students explore current approaches to the design and implementation of centralized, distributed, and internet-based information systems (data warehouses or web-basec distributed information systems).         Course components and teaching format(s)       Lecture Databases and Information Systems (4 credit hours per week)         Evercises/Seminar Databases and Information Systems (3 a sequencises/seminar. Participation in the exercises/Seminar Databases and Information Systems)<		M.Sc. IT Management and Consulting: Required elective a	area — IT d	levelopme	nt			
and Management of Information Systems M.S.C. Intelligent Adaptive Systems: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics M.S.C. Intelligent Adaptive Systems: Required elective area Prerequisites Maddatory: none Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL); basic knowledge of formal logic (Horn clause logic, predicate calculus) Module coordinator(s) Professur Data Engineering Teaching staft Professur Data Engineering, N.N. Language English with teaching materials in English Qualification targets Students have in-depth knowledge of the basic principles, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems). Contents Students explore current approaches to the design and implementation of centralized, distributed, and Internet-based information systems. Focus areas: current database technology, object-relational database systems; data, web, and text mining; and the Semantic Web. Course components and teaching format(s) Exercises/Seminar Databases and Information Systems [3 28 70 20 ToTal workload (course components and overall) (course components and overall formatios;: Regular and successful participation in the exercises/Seminar. Participation in the exercises /Seminar Databases and Information Systems [3 28 70 20 ToTal workload (course order solved correcity. Participation in the exercises/Seminar. Participation in the exercises /Seminar Databases and Information Systems [3 28 70 20 ToTal workload exercises /Seminar Databases and Information Systems [3 28 70		M.Sc. Information Systems: Required elective area – Infor	matics ur	nd Speciali	zation – D	evelopment		
M.Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences, informatics, and bioinformatics         Prerequisites       M.Ac. Intelligent Adaptive Systems: Required elective area         Prerequisites       Mandatory: none         Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQ); basic knowledge of formal logic (Horn clause logic, predicate calculus)         Module coordinator(s)       Professur Data Engineering         Teaching staff       Professur Data Engineering, N.N.         Language       English with teaching materials in English         Qualification targets       Students have in-depth knowledge of the basic principles, oncepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).         Contents       Students explore current approaches to the design and implementation of centralized, distributed, and internet-based information Systems.         Course components and teaching format(s)       Lecture Databases and Information Systems (4 credit hours per week)         Exercise/Seminar Databases and Information Systems       G       56       56       60         Course components and		and Management of Information Systems						
Informatics, and bioinformatics         MSc. Intelligent Adaptive Systems: Required elective area         Prerequisites       Mandatory: none         Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebra, SQL); basic knowledge of formal logic (Horn clause logic, predicate calculus)         Module coordinator(s)       Professur Data Engineering         Teaching staff       Professur Data Engineering, NN.         Language       English with teaching materials in English         Qualification targets       Students have in-depth knowledge of the basic principles, concepts, and methods of datamanagement, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).         Contents       Students explore current approaches to the design and implementation of centralized, distributed, and intermet-based information systems. Focus areas: current database technology: object-relational database systems; especially transaction management; distributed data management and web acces; data warehousing; data, web, and text mining; and the Semantic Web.         Workload       Exercises/Seminar Databases and Information Systems is Credit hours per week/         Course components and teaching       Exercises/Seminar Databases and Information Systems is 2 8 70 20		M.Sc. Bioinformatics: Required elective area – informatics	Sc. Bioinformatics: Required elective area – informatics und Required elective area – life sciences,					
M.Sc. Intelligent Adaptive Systems: Required elective area         Prerequisites       Mandatory: none         Recommended: In-depth knowledge of the relational database model (ER modeling, normalization, relational algebras, SQL) basic knowledge of semi-structured data management (XML, XML schema, XML query language); basic knowledge of formal logic (Horn clause logic, predicate calculus)         Module coordinator(s)       Professur Data Engineering, NN.         Language       English with teaching materials in English         Qualification targets       Students have in-depth knowledge of the basic principles, concepts, and methods of data management, data preparation, and data analysis. They are able to handle data and knowledge assets and to conceptualize and implement database and information systems and adapt database systems to specific application circumstances. They are moreover aware of the possibilities for integrating database solutions into complex software systems (data warehouses or web-based distributed information systems).         Contents       Students explore current approaches to the design and implementation of centralized, distributed, and Internet-based information systems. Focus areas: current database schoology; object-relational database systems, especially transaction management, distributed data management and web access; data warehousing; data, web, and text mining; and the Semantic Web.         Course components and teaching       Lecture Databases and Information Systems (2 credit hours per week)         format(s)       Lecture Databases and Information Systems       3 28 70 20         total workload       9 84 126 60       60 <td></td> <td colspan="5">formatics, and bioinformatics</td>		formatics, and bioinformatics						
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Academic requirements and examinationsCoursework: Regular and successful participation in the exercises/seminar. Participation in the exercises is deemed to have been successful if all of the assignments have been completed and at least 50 % have been solved correctly. Participation in the seminar is deemed to have been successful if the respective topic area has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.Module duration1 semesterSemester(s) offeredSummer semester, every year		Exercises/seminar DataDases and information systems	3	28	10	20		
Academic requirements and examinationsCoursework: Regular and successful participation in the exercises/seminal. Participation in the exercises is deemed to have been successful if all of the assignments have been completed and at least 50 % have been solved correctly. Participation in the seminar is deemed to have been successful if the respective topic area has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.Module duration1 semesterSemester(s) offeredSummer semester, every year	Acadomic requirements and	Coursework, Pogular and successful participation in the	yorcicoc <i>l</i> i	04 cominar D	120 Participatio	00 n in the		
ExaminationsExercises is deemed to have been successful if an of the assignments have been completed and at least 50 % have been solved correctly. Participation in the seminar is deemed to have been successful if the respective topic area has been understood, appropriately presented, and, if applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.Module duration1 semesterSemester(s) offeredSummer semester, every year	Academic requirements and	eversions is deemed to have been successful if all of the a	ccignmon	te have he	anticipatio	tod and at		
IterationModule durationSemester(s) offeredSemester(s) offeredSummer semester, every year		least 50 % have been solved correctly. Darticipation in the	sominari	is nave be	to have he	and and at		
In the respective copic area has been understood, appropriately presented, and, in applicable, explored appropriately in writing. Any changes to the criteria must be announced prior to module registration.         Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.         Module duration       1 semester         Semester(s) offered       Summer semester, every year		if the respective tonic area has been understood appropr	istely pro	s uccilicu contod an	d if applic	ahla		
Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.         Module duration       1 semester         Semester(s) offered       Summer semester, every year		explored appropriately in writing. Any changes to the crit	eria must	he annou	nced prior	to module		
Integration:       Exam(s): Joint examination for all module courses, generally a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.         Grades will be awarded for the module examination(s).         Module duration       1 semester         Semester(s) offered       Summer semester, every year		registration	explored appropriately in writing. Any changes to the criteria must be announced prior to module					
Initial and the examination of a minimum of the module courses, generatly a written examination in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration.         Grades will be awarded for the module examination(s).         Module duration       1 semester         Semester(s) offered       Summer semester, every year		Exam(s): Joint examination for all module courses genera	ally a writ	ten exami	nation in t	he teaching		
Images of the order of the		language Alternatively an oral examination may be poss	ible The	examinati	on type(s)	will be		
Module duration     1 semester       Semester(s) offered     Summer semester, every year		announced prior to module registration	Die. The	cxummuti	on type(s)	Will be		
Module duration     1 semester       Semester(s) offered     Summer semester, every year		Grades will be awarded for the module examination(s)						
Semester(s) offered     Summer semester, every year	Module duration	1 semester						
	Semester(s) offered	Summer semester, every year						
Literature	Literature							

Module title	Distributed Systems and Middleware							
Module number/code	InfM-DSM							
Module applicability, type and	M.Sc. Informatics: Advanced modules							
curricular area	M.Sc. Intelligent Adaptive Systems: Elective Area							
Prerequisites	Mandatory: none							
	Recommended: Kenntnisse zu Rechnernetzen, verteilten	Systemen	n, Systems	icherheit u	nd			
	Programmierkenntnisse	-	-					
Module coordinator(s)	Edinger							
Teaching staff	Edinger, N.N.							
Language	English with teaching materials in English							
Qualification targets	Students understand the advanced challenges of distribu	ted syster	ms. They a	are able to	explain the			
	different models of distributed systems. Students can exp	plain and i	implemer	it basic alg	orithms for			
	error detection, leader election, broadcast and multicast,	consensu	s protocol	s and grou	р			
	communication. They know the purpose of middleware in	n distribut	ted syster	ns. Studen	ts can design			
	and implement entities and communication in distribute	d systems	s for select	ted scenari	os.			
Contents	The lecture deals with advanced research questions in the	e field of o	distributed	d systems a	nd			
	middleware. Building on basic knowledge of computer ne	etworks a	nd distrib	uted syster	ns, the course			
	will focus in particular on algorithms used in complex dis	tributed s	systems. F	urthermor	e, knowledge			
	about the functionality and use of middlewares is impart	ed and di	scussed u	sing currer	t examples			
	from research.			U	·			
	The following topics are generally covered:							
	Error detection in distributed systems							
	Leader Election							
	<ul> <li>Reliable broadcast and epidemic algorithms</li> </ul>							
	Consensus protocols							
	<ul> <li>Group communication and synchronization</li> </ul>							
	<ul> <li>Distributed state detection</li> </ul>							
	<ul> <li>Exclusion in distributed systems</li> </ul>							
	Logical clocks							
	Replication							
	<ul> <li>Distributed computation (including MapReduce)</li> </ul>							
	<ul> <li>Middleware (distributed objects, name services, rel</li> </ul>	mote met	hod calls)					
	In the accompanying exercise, students design and develo	op a distri	buted sys	tem with a	special focus			
	on the algorithms covered in the lecture. Each semester, t	he focus	will be on	a different	topic. The			
	design and implementation are presented and discussed	within th	e group as	s part of th	e exercises.			
Course components and teaching	Lecture Distributed Systems and Middleware (2 credit ho	urs per we	eek)					
format(s)	Exercises Distributed Systems and Middleware (2 credit h	ours per v	veek)					
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)			
(course components and overall)	Lecture Distributed Systems and Middleware	3	28	42	20			
	Exercises Distributed Systems and Middleware	3	28	42	20			
	Total workload	6	56	84	40			
Academic requirements and	Coursework: Regular and successful participation in the e	exercises.	Participat	ion in the e	exercises is			
examinations	deemed successful when a suitable distributed system w	as develo	ped and p	resented a	s part of the			
	exercises. Any changes to the criteria must be announced	l prior to r	module re	gistration.				
	Exam(s): Joint examination for all module courses; generally, a written examination in the teaching							
	language. Alternatively, an oral examination may be poss	ible. The	examinat	ion type(s)	will be			
	announced prior to module registration.							
	Grades will be awarded for the module examination(s).							
Module duration	1 semester							
Semester(s) offered	Winter semester, every year							
Literature	Distributed Systems: Concepts and Design; George Coulo	uris, Jean	Dollimore	e, Tim Kind	berg, Gordon			
	Blair: 5. Ausgabe, Pearson Verlag				-			

Module title	Intelligent Robotics						
Module number/code	InfM-IR						
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection						
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial						
	Intelligence und Domain Knowledge in Data Science and	Artificial	Intelligend	e: Informa	atics		
	M.Sc. IT Management and Consulting: Required elective	area — IT c	levelopme	ent			
	M.Sc. Intelligent Adaptive Systems: Required modules						
Prerequisites	Mandatory: none						
	Recommended: Basic knowledge of knowledge processir	ıg					
Module coordinator(s)	Zhang						
Teaching staff	Zhang, N.N.						
Language	English with teaching materials in English						
Qualification targets	Students are familiar with the physical forms of perception	on in term	ns of their	applicatio	ns in robotics.		
	They can apply sensor-based techniques in robotics and c	other tech	nical syste	ems. They	master basic		
	techniques of intelligent systems and understand their p	ossible ap	plications	in technic	al systems.		
	They will have an overview of application areas and impl	ementatio	on approa	ches for m	achine		
	learning methods.						
Contents	General sensor characteristics and classification, integrat	ed sensor	data proc	essing, ser	nsors for		
	various measurement modalities (e.g. haptic, visual), per	ception-a	ction cycle	s, robot be	havior		
	control architectures, multisensor fusion and filtering, ap	plications	s of machi	ne learning	g approaches		
	in robotics.	•					
Course components and teaching	Lecture Intelligent Robotics (2 credit hours per week)						
format(s)	Seminar Intelligent Robotics (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Intelligent Robotics	3	28	42	20		
	Seminar Intelligent Robotics	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the	seminar (s	seminar w	ork and a p	presentation		
examinations	in the teaching language).						
	Exam(s): Generally, an oral examination in the teaching l	anguage (	on all of t	he content	covered		
	during the lecture and seminar). Alternatively, a written e	examinati	on is poss	ible. The e	xamination		
	type(s) will be announced prior to module registration.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Winter semester, every year						
Literature							

Module title	Independent Study						
Module number/code	InfM-IS/IAS						
Module applicability, type and curricular area	M.Sc. Intelligent Adaptive Systems: Required elective are	а					
Prerequisites	Mandatory: none						
	Recommended: none						
Module coordinator(s)	Wermter						
Teaching staff	Wermter, N.N.						
Language	English with teaching materials in English						
Qualification targets	Students are able to independently expand and deepen their knowledge and skills in the field of intelligent adaptive systems. They can independently analyze problems and develop proposals for solutions using informatics concepts, while placing special emphasis on intelligent adaptive systems. They are able to present their findings in writing and during a presentation.						
Contents	Students learn to use scientific tools to analyze a practical problem and develop a solution. They prepare a written paper and present their findings in a colloquium. With this module, they pick up an issue in informatics and examine it using concepts from informatics. Students consult with their supervisor regularly during the study: this can take place during a seminar						
Course components and teaching format(s)	Betreute Projektstudie (no scheduled course, therefore n	o credit ho	ours per w	eek)			
	Student may choose between a workload of 3 ECTS or 6 E multiple times, up to a total of 6 ECTS in required elective (including free electives).	CTS. May es and 12 I	be conduce CTS overa	cted all			
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Betreute Projektstudie	3/6	0	75/150	15/30		
	Total workload	3/6	0	75/150	15/30		
Academic requirements and	Coursework: none			4			
examinations	Exam(s): Generally, a presentation and a term paper, both	h in Englis	h. An ove	rall final gr	ade will be		
	awarded for the presentation and term paper.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Every semester, every year						
Literature							

Module title	Language Technology						
Module number/code	InfM-LT						
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Data Science	e: Selecti	on				
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced T	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial					
	Intelligence und Domain Knowledge in Data Science and	Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics					
	M.Sc. Intelligent Adaptive Systems: Required elective area	a	0				
Prereguisites	Mandatory: none						
	Recommended: Basic knowledge of automatic language	Recommended: Basic knowledge of automatic language processing, basic knowledge of machine					
	learning						
Module coordinator(s)	Biemann						
Teaching staff	Biemann NN						
	English with teaching materials in English						
Qualification targets	Students gain in-denth knowledge in selected areas of th	e machin	e processi	ng of natu	ral language		
Quanneation targets	They are able to access the viability and transferability of	mothode	of natural		processing		
	They are able to assess the viability and transferability of methods of natural language processing						
Contonto	Students learn the algorithmic and methodological found	Intuings.	naturalla	nguago m	achina		
contents	processing		fiaturaria	nguage m	achine		
	processing.			ud fauna a 7			
	How does language technology work? How does the con	iputer rec	ognize wo	ru iorriis?	How Can		
	synonyms be used for the search? Students examine the	use of alg		i speech te	echnology		
	applications. In addition to machine learning and data sti	ructures t	or storing	and manip	bulating text,		
	applications such as machine translation and semantic se	arches ar	e explored	i. The prac			
	language processing software is considered and the theory	ry consoli	uated in tr	ie accomp	anying		
	practical course.						
	A selection of the topics covered:						
	computer morphology						
	sequence classification						
	• topic modeling						
	distributional semantics						
	statistical machine translation						
	neural methods of language comprehension						
	distributional semantics						
	word meaning and disambiguation						
	large language models						
Course components and teaching	Lecture Language Technology (2 credit hours per week)						
format(s)	Exercises Language Technology (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Language Technology	3	28	42	20		
	Exercises Language Technology	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the e	exercises.	Participat	on in the	exercises is		
examinations	deemed successful when all of the exercises have been co	mpleted	and at lea	st 50 % hav	ve been		
	solved correctly. Any changes to the criteria must be anno	bunced pr	ior to mod	ule registi	ration.		
	Exam(s): Joint examination for all module courses, genera	ally a writ	ten exami	nation in t	he teaching		
	language. Alternatively, an oral examination may be poss	ible. The	examinati	on type(s)	will be		
	announced prior to module registration.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Summer semester, every year						
Literature	Jurafsky, D. and Martin, J. H. (2009): Speech and Language	e Processi	ng. An Int	roduction	to Natural		
	Language Processing, Computational Linguistics and Spec	ech Recog	nition. See	cond Editio	on. Pearson:		
	New Jersev	0					
	Manning, C. D. and Schütze, H. (1999): Foundations of Sta	tistical N	atural Lan	guage Pro	cessing. MIT		
	Press: Cambridge, Massachusetts			5 . 0	- 0,		
	Carstensen, K. U., Ebert, Ch., Endriss, C., Jekat, S., Klabund	e, R. and L	anger. H. (	Editors) (2	004):		
	Computerlinguistik und Sprachtechnologie. Fine Finführ	ung. 2 <sup>nd</sup> e	dition Sne	ktrum H	eidelberg		
	Further topic-specific literature						

Module title	Final Module M.Sc. Intelligent Adaptive Systems						
Module number/code	InfM-MA/IAS						
Module applicability, type and	M.Sc. Intelligent Adaptive Systems: Required modules						
curricular area							
Prerequisites	Mandatory: Vgl. §14 der MIN-PO sowie die FSB zu §14						
	Recommended: none	lecommended: none					
Module coordinator(s)	Studiengangsverantwortliche(r)						
Teaching staff	Gemäß Beschluss des Prüfungsausschusses						
Language	English with teaching materials in English						
Qualification targets	<ul> <li>Students possess the ability to work independently on a complex, scientific problem from the field of informatics using scientific methods</li> <li>They possess advanced problem-solving skills and the ability to transfer the theoretical and methodological knowledge of informatics to new areas of application</li> <li>They are able to scientifically evaluate and classify their own work against the background of current research work regarding the chosen topic</li> <li>They are able to document problem analyses, approaches to solutions, and empirical findings in accordance with scientific standards</li> <li>They are able to present, scientifically evaluate, and discuss the approaches to solutions both verbally and in writing.</li> </ul>						
Contents	<ul> <li>Das Thema der Arbeit sollte die Entwicklung, Verfeinerung, Implementierung und/oder Validierung einer informatischen Methode umfassen. Die Bearbeitung erfolgt in der Regel in folgenden Phasen:</li> <li>Einarbeitung in die Thematik und in den aktuellen Stand der Forschung</li> <li>Erarbeitung/Auswahl der Methoden und Techniken zur Problemlösung</li> <li>Entwicklung eines Lösungskonzeptes</li> <li>Implementierung/Realisierung des eigenen Konzeptes/Ansatzes</li> <li>Validierung und Bewertung der Ergebnisse</li> <li>Wissenschaftliche Darstellung der Ergebnisse in schriftlicher Form und als Referat mit anschließender Diskussion</li> </ul>						
Course components and teaching	Masterarbeit und Präsentation in einem Kolloquium (no	schedulec	l course, t	herefore n	o credit hours		
	Zur Dauer siehe § 14 der Prüfungsordnung der Fakultät fü Naturwissenschaften für Studiengänge mit dem Abschlu Fachspezifischen Bestimmungen zu § 14 (Masterarbeit).	ir Mathen Iss Master	natik, Info of Scienc	rmatik und e sowie die	2		
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Masterarbeit und Präsentation in einem Kolloquium	30	-	-	-		
	Total workload	30	-	-	-		
Academic requirements and	Coursework: none						
examinations	Exam(s): Masterarbeit (90 %) und Kolloquium (10 %). Näheres zur Modulprüfung regelt § 14 der Prüfungsordnung der Fakultät für Mathematik, Informatik und Naturwissenschaften für Studiengänge mit dem Abschluss "Master of Science" sowie die Fachspezifischen Bestimmungen zu § 14 (Masterarbeit). Grades will be awarded for the module examination(s).						
Module duration	see details						
Semester(s) offered	Every semester						
Literature							

Module title	Machine Learning					
Module number/code	InfM-ML					
Module applicability, type and	M.Sc. Informatics: Required elective area – general und Re	equired e	lective are	a – theory	//Focus Data	
curricular area	Science: At least two out of InfM-DIS, InfM-ML, InfM-STSF	)				
	M.Sc. Data Science and Artificial Intelligence: Required ele	ective are	a — Funda	mentals o	of Data Science	
	and Artificial Intelligence und Domain Knowledge in Data	Science	and Artific	ial Intellig	gence:	
	Informatics					
	M.Sc. Bioinformatics: Required elective area – informatics	und Req	uired elect	tive area -	- life sciences,	
	informatics, and bioinformatics					
	M.Sc. Intelligent Adaptive Systems: Required modules					
Prerequisites	Mandatory: none					
	Recommended: Basic knowledge of linear algebra, stocha	ecommended: Basic knowledge of linear algebra, stochastics, data mining, Python				
Module coordinator(s)	Laue					
Teaching staff	Laue, N.N.					
Language	English with teaching materials in English					
Qualification targets	Students have in-depth knowledge of the various approa	ches to le	arning fro	m data, ir	cluding their	
_	limitations. They are able to compare learning methods in	n terms o	f specific a	pplicatio	n conditions.	
	They are able to systematically classify new procedures. T	hey can d	lesign, im	olement, a	and evaluate a	
	learning system for a given task. They can present empiri	cal findin	gs from th	e field of	machine	
	learning.					
Contents	Theoretical foundations of machine learning; Bias-varian	ce trade-o	off; Regula	rization; I	Nodel	
	selection and model evaluation; Supervised learning met	hods for 1	egression	and class	ification	
	(linear methods, non-linear methods, kernel methods, de	cision tre	es); Metho	ods of uns	upervised	
	learning (dimension reduction, clustering, matrix comple	learning (dimension reduction, clustering, matrix completion); Reinforcement learning.				
Course components and teaching	Lecture Machine Learning (4 credit hours per week)					
format(s)	Exercises/Seminar Machine Learning (2 credit hours per v	/eek)				
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)	
(course components and overall)	Lecture Machine Learning	6	56	56	40	
	Exercises/Seminar Machine Learning	3	28	70	20	
	Total workload	9	84	126	60	
Academic requirements and	Coursework: Regular and successful participation in the e	xercises/	seminar. F	Participati	on in the	
examinations	exercises is deemed to have been successful if all of the a	ssignmer	its have be	en compl	eted and at	
	least 50 % have been solved correctly. Participation in the	seminar	is deemed	to have b	een successful	
	if the respective topic area has been understood, appropr	iately pre	sented, ar	ıd, if appli	cable,	
	explored appropriately in writing. Any changes to the crit	eria must	t be annou	inced prio	r to module	
	registration.					
	Exam(s): Joint examination for all module courses, genera	ally a writ	ten exami	nation in	the teaching	
	language. Alternatively, an oral examination may be poss	ible. The	examinati	on type(s	) will be	
	announced prior to module registration.					
	Grades will be awarded for the module examination(s).					
Module duration	1 semester					
Semester(s) offered	Summer semester, every year					
Literature						

Module title	Network Security						
Module number/code	InfM-NetSec						
Module applicability, type and	M.Sc. Informatics: Required elective area – general / Focus IT-Security: At least one of InfM-NetSec,						
curricular area	InfM-SbD						
	M.Sc. IT Management and Consulting: Elective Area						
	M.Sc. Information Systems: Elective Area						
	M.Sc. Bioinformatics: Elective Area						
	M.Sc. Intelligent Adaptive Systems: Elective Area						
Prerequisites	Mandatory: none						
	Recommended: Kenntnisse im Bereich Algorithmik, Math	ematik, F	Rechnerne	tze, verteil	te Systeme,		
	IT-Sicherheit						
Module coordinator(s)	Fischer						
Teaching staff	Fischer, N.N.						
Language	German with teaching materials in English or English wit	h teachin	g materia	ls in Englis	h		
Qualification targets	Students have a basic understanding of threats and attac	ks to net	works as v	vell as netv	work security		
	mechanisms and security protocols. They are able to appl	y their kr	iowledge i	in practice	to secure		
	communication via networks as well as the networks the	mselves.	They can a	also perfor	m forensic		
	analyses (e.g., using network data) and are proficient in u	sing the o	orrespond	ding tools.	Students are		
	able to work in smaller groups to develop solutions to pro	blems.					
Contents	Topics:						
	<ul> <li>attacks on networks and networked systems</li> </ul>						
	<ul> <li>cryptographic protocols in network security</li> </ul>						
	<ul> <li>network security protocols at various levels of the I</li> </ul>	nternet n	nodel				
	<ul> <li>protection of critical Internet services</li> </ul>						
	<ul> <li>network monitoring and forensics</li> </ul>						
	The lecture is complemented with a practical course durin	ng which	students e	explore the	e material		
	covered during the lecture in greater depth, mainly by wo	rking on	practical t	asks in sm	all groups.		
Course components and teaching	Lecture Network Security (4 credit hours per week)				<u> </u>		
format(s)	Exercises Network Security (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Network Security	6	56	84	40		
	Exercises Network Security	3	28	42	20		
	Total workload	9	84	126	60		
Academic requirements and	Coursework: Regular and successful participation in the e	xercises.	Participat	ion in the	exercises is		
examinations	deemed to have been successful if the respective topic ha	s been ur	nderstood	, appropria	itely		
	presented, and, if applicable, explored appropriately in w	riting. An	y changes	will be an	nounced prior		
	to module registration.				·		
	Exam(s): Joint examination for all module courses; generation	ally, an or	al examin	ation in th	e teaching		
	language. Alternatively, a written examination is possible	e. The exa	mination	type(s) wil	lbe		
	announced prior to module registration.			<i>.</i>			
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Summer semester, every year						
Literature	G. Schäfer, M. Rossberg. Netzsicherheit. dpunkt.verlag, 67	'6 pages,	Hardcover	; 2014.			
	W. Stallings. Cryptography and Network Security: Princip	les and Pi	ractice. Ha	rdcover, 75	52 pages,		
	Pearson, 8th edition, 2020.						
	C. Eckert. IT-Sicherheit: Konzepte, Verfahren, Protokolle. z	ehnte Au	lflage, Old	enbourg V	erlag, 932		
	pages, 2018.		0,	0	0.		

Module title	Neural Networks						
Module number/code	InfM-NN						
Module applicability, type and	M.Sc. Informatics: Advanced modules						
curricular area	M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science						
	and Artificial Intelligence und Domain Knowledge in Data	Science	and Artifi	ial Intellig	ence:		
	Informatics						
	M.Sc. Bioinformatics: Required elective area – informatics	und Req	uired elec	tive area –	life sciences,		
	informatics, and bioinformatics						
	M.Sc. Intelligent Adaptive Systems: Required modules						
Prerequisites	Mandatory: none						
	Recommended: Knowledge in bio-inspired artificial intell	igence					
Module coordinator(s)	Wermter						
Teaching staff	Wermter, N.N.						
Language	English with teaching materials in English						
Qualification targets	Students have an in-depth understanding of artificial neu	Iral netwo	orks and t	heir integr	ation into		
_	informatics architectures. They can analyze and understa	nd compl	lex proble	ms and de	velop		
	adequate solutions for them.						
Contents	Students are introduced to current research in knowledge	processi	ng with n	eural netw	orks, enabling		
	them to participate in research under guidance. The lectu	ire provid	es a comp	rehensive	overview of		
	artificial neural networks and their use and integration in	to hybrid	neural/sy	mbolic sys	stems. In the		
	seminar, models from the latest research are evaluated ar	nd linked	to the ma	terial cove	red in the		
	lecture. The changing topics explored during the seminar	are deter	rmined be	fore the st	art of the		
	academic year to take into account changing demands an	d current	research	directions.			
	Lecture topics:						
	<ul> <li>neural networks: from basic models to advanced n</li> </ul>	etworks					
	<ul> <li>unsupervised and reinforcement learning with neural networks</li> </ul>						
	<ul> <li>hybrid symbolic and neural architectures</li> </ul>						
	<ul> <li>neural clustering and classification</li> </ul>						
	<ul> <li>neural models for cognitive processing</li> </ul>						
	<ul> <li>neuroscience-inspired architectures for cognitive re</li> </ul>	obots					
Course components and teaching	Lecture Neural Networks (2 credit hours per week)						
format(s)	Seminar Neural Networks (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Neural Networks	3	28	42	20		
	Seminar Neural Networks	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the s	eminar. F	Participati	on in the s	eminar is		
examinations	deemed to have been successful if the respective topic ha	s been ur	nderstood	appropria	ntelv		
	presented, and, if applicable, explored appropriately in wi	riting. An	v changes	to the crit	eria must be		
	announced prior to module registration.	- 0-					
	Exam(s): Joint examination for all module courses; genera	ally, an or	al examin	ation in th	e teaching		
	language. Alternatively, a written examination is possible	. The exa	mination	type(s) wil	l be		
	announced prior to module registration.			-71 - 1-7	-		
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Summer semester, every year						
Literature	Haykin S.: Neural networks and learning machines. Prent	ice Hall, 2	2008				
	Wermter S., Sun R.: Hybrid Neural Systems. Springer Verla	ng. Heidel	berg, 200	0			

Module title	Optimization for Machine Learning					
Module number/code	InfM-OML					
Module applicability, type and	M.Sc. Informatics: Advanced modules					
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial					
	Intelligence und Domain Knowledge in Data Science and	Artificial	Intelligenc	e: Informa	atics	
	M.Sc. Bioinformatics: Required elective area – informatics	s und Req	uired elect	tive area –	life sciences,	
	informatics, and bioinformatics					
	M.Sc. Intelligent Adaptive Systems: Elective Area					
Prerequisites	Mandatory: none					
	Recommended: InfM-ML, basic knowledge of linear algeb	ora, analys	sis, Pythor	1		
Module coordinator(s)	Laue					
Teaching staff	Laue, N.N.					
Language	English with teaching materials in English					
Qualification targets	Many problems in the field of machine learning and artifi	icial intell	igence req	uire the so	olution of an	
	optimization problem. This applies to both classical mach	nine learn	ing and m	odern dee	p learning	
	nethods. The theoretical foundations of optimization algorithms and their practical					
	implementation in Python are covered with a special focu	is on mac	hine learn	ing proble	ms. Students	
	know and understand the theoretical guarantees/runtim	es and lin	nits of vari	ous optim	ization	
	algorithms. They know which algorithm to choose for a s	pecific ma	achine leai	rning prob	lem and how	
	to efficiently implement optimization algorithms for mac	hine learı	ning. They	are aware	of numerical	
	robustness and rounding errors in optimization algorithm	ıs.				
Contents	The theoretical foundations of optimization algorithms a	s well as t	their pract	ical impleı	mentation	
	and application to machine learning are covered. This me	ans that o	different a	lgorithms	are	
	introduced and their running times are analyzed, lower b	ounds for	different	function c	asses are	
	proven and these algorithms are implemented in Python	and appli	ed to diffe	rent mach	ine learning	
	problems. Therefore, prior knowledge of linear algebra, analysis and probability theory as well as					
	knowledge of writing Python code is essential.					
	In particular, the following topics are covered in more detail:					
	<ul> <li>Fundamentals of optimization, where optimization</li> </ul>	Fundamentals of optimization, where optimization is used in machine learning				
	General algorithms for solving unconstrained optimization problems including their runtime					
	analysis					
	<ul> <li>Specialized algorithms that are often used in mach</li> </ul>	ine learni	ing, e.g. Fra	ank-Wolfe	methods,	
	conditional gradient descent, coordinate descent, p	proximal r	nethods			
	<ul> <li>Optimization problems with general constraints ar</li> </ul>	nd algoritl	hms to sol	ve them, d	luality theory	
	<ul> <li>Optimization algorithms used for large problems a</li> </ul>	nd deep l	earning, e	.g. various	stochastic	
	gradient descent methods such as SGD, Adam, Ada	Grad, RM	SProp			
	Efficient calculation of matrix and tensor derivative	es, algorit	hmic diffe	rentiation	(AD)	
Course components and teaching	Lecture Optimization for Machine Learning (2 credit hour	s per wee	k)			
format(s)	Exercises Optimization for Machine Learning (2 credit hou	irs per we	eek)			
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)	
(course components and overall)	Lecture Optimization for Machine Learning	3	28	42	20	
	Exercises Optimization for Machine Learning	3	28	42	20	
	Total workload	6	56	84	40	
Academic requirements and	Coursework: Regular and successful participation in the e	exercises.	Participat	ion is deer	ned to have	
examinations	been successful if a solution has been presented at least of	once durii	ng the exe	rcises and	a solution	
	successfully presented for the exercises accompanying th	e entire le	ecture pha	se. Any ch	anges to the	
	criteria must be announced prior to module registration.					
	Exam(s): Joint examination for all module courses, genera	ally a writ	ten exami	nation (90	) minutes) in	
	the teaching language. Alternatively, an oral examination	ı may be p	possible. T	he examir	nation type(s)	
	will be announced prior to module registration.					
	Grades will be awarded for the module examination(s).					
Module duration	1 semester					
Semester(s) offered	Winter semester, every year					
Literature						

Module title	Project						
Module number/code	InfM-Proj						
Module applicability, type and	M.Sc. Informatics: Required area						
curricular area	M.Sc. Intelligent Adaptive Systems: Required modules						
Prerequisites	Mandatory: none	Mandatory: none					
	Recommended: Individuelle Projekte können spezifische	inhaltlich	e Vorauss	etzungen e	empfehlen.		
Module coordinator(s)	Studiengangsverantwortliche(r)						
Teaching staff	Lehrende des Fachbereichs Informatik, N.N						
Language	German with teaching materials in German and possibly	in English	ı or Englis	h with tead	ching		
	materials in English						
Qualification targets	Die Studierenden haben die Fähigkeit zur Einarbeitung in	Die Studierenden haben die Fähigkeit zur Einarbeitung in neue Aufgabenstellungen und zum Lösen					
	anspruchsvoller Informatik-Aufgaben mit wissenschaftlichen Methoden (unter Anleitung) im Team						
	erlangt. Sie besitzen vertiefte Fähigkeit zur selbstständig	en Erarbei	itung fach	licher Inha	lte aus der		
	Originalliteratur und zur Präsentation fremder und eigen	er Probler	nstellung	en und -lös	sungen in		
	Referat und schriftlicher Form.						
Contents	Die typischen Phasen eines Entwicklungsprojektes werde	en unter d	er beruflio	hen Praxis	;		
	weitestgehend entsprechenden Rahmenbedingungen im	i Team du	rchlaufen	, um berufs	sbefähigende		
	Kompetenzen zu vermitteln. Wissenschaftliches Arbeiter	n wird gefö	ördert, da	aktuelle			
	Forschungsinhalte aufgegriffen und verarbeitet werden s	ollen, um	die Proble	emlösungs	kompetenz		
	zu erweitern. Des Weiteren wird die Transferkompetenz l	pesonders	gestärkt,	da der The	eorie- und		
	Methodenschatz der Informatik auf komplexe, neuartige	Probleme	e anzuwer	nden ist. No	eben der		
	Bearbeitung größerer theoretischer, konstruktiver und/oc	der experi	menteller	Aufgaben	(in der Regel		
	Systementwicklung nach Softwaretechnik-Methoden) in	einem Inf	ormatik-F	achgebiet	ist die		
	Recherche aktueller, wissenschaftlicher Publikationen zu	m übergeo	ordneten	Projektthe	ma und		
	gegenseitige Vermittlung der inhaltlichen Grundlagen de	er Ergebnis	sse im inte	egrierten S	eminar		
	integraler Bestandteil des Projekts.						
Course components and teaching	Project (6 credit hours per week)						
format(s)	Integrated Seminar (2 credit hours per week)						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Project	9	84	126	60		
	Integrated Seminar	3	28	42	20		
	Total workload	12	112	168	80		
Academic requirements and	Coursework: Die Zulassung zur Modulprüfung setzt die a	ktive Teilr	nahme an	dem Proje	kt und dem		
examinations	integrierten Seminar, eine kontinuierliche Beteiligung sow	wie eine e	rfolgreich	e Projektm	itarbeit und		
	die Vorstellung der Ergebnisse/Lösungsansätze in Referat	und schr	iftlicher A	usarbeitur	ig voraus.		
	Exam(s): Projektabschluss in Form eines Abschlussberichts in der Unterrichtssprache für Projekt und				ir Projekt und		
	integriertes Seminar						
	Grades will be awarded for the module examination(s).						
Module duration	1-2 semesters						
Semester(s) offered	Every semester						
Literature							

Module title	Quantitative Analysis of Software Architectures					
Module number/code	InfM-QASA					
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Software E	ngineerin	g: Selectio	n		
curricular area	M.Sc. Intelligent Adaptive Systems: Elective Area					
Prerequisites	Mandatory: none					
	Recommended: InfM-SWA; Grundkenntnisse und Interes	se in Soft	ware-Engi	neering un	d	
	Software-Qualität					
Module coordinator(s)	Professur Softwarearchitektur					
Teaching staff	Professur Softwarearchitektur, N.N.					
Language	English with teaching materials in English					
Qualification targets	Students are able to document, analyze, and interpret qu	antitative	e requirem	ents and p	roperties of	
	software architectures using descriptive and prescriptive	modeling	formalisn	ns as well a	as model- and	
	measurement-based evaluation methods, techniques, an	measurement-based evaluation methods, techniques, and tools.				
Contents	Software quality is key to the success of software system	Software guality is key to the success of software systems. Students are introduced to relevant				
	principles of quantitative software quality attributes and	modeling	g formalisr	ns during t	the lecture,	
	whereby the focus is on software runtime quality attribu	tes. Buildi	ing on this	, quantitat	ive	
	assessment approaches are presented using design and a	inalysis m	odels and	measurem	nent-based	
	approaches such as load and resilience testing, monitorir	ng, and be	nchmarki	ng as well a	as advanced	
	approaches and the latest research findings. The concept	s covered	during the	e lecture ai	re discussed,	
	applied, and explored in greater depth during the practic	al course i	using exar	nples and t	tools.	
	Topics covered:					
	<ul> <li>metrics and objective values of software runtime of</li> </ul>	uality wit	h a focus	on perform	nance,	
	availability, scalability, elasticity, and resilience, inc	luding sta	itistical for	undations		
	<ul> <li>descriptions of software architecture (UML2 profile</li> </ul>	es and DSI	Ls) with qu	antitative	properties	
	<ul> <li>probabilistic analysis modeling formalisms and sol</li> </ul>	ution tecl	nniques, e	.g., Markov	r chains,	
	queuing models (variants), Petri nets (variants), an	d fault tre	es			
	<ul> <li>transformations between design and analysis mod</li> </ul>	lels and th	neir finding	gs		
	measurement-based techniques, e.g., load and res	lience tes	ting/benc	hmarks an	d monitoring	
	advanced topics, e.g., scenario-based architecture a	assessmei	nt, trade-o	ff analysis,		
	multi-objective optimization, model extraction/cal	ibration, a	and hybrid	assessme	nt	
	approaches, that is, the combination of models and	a measure	ements			
Course components and teaching	Lecture Quantitative Analysis of Software Architectures (	2 credit ho	ours per w	eek)		
format(s)	Exercises Quantitative Analysis of Software Architectures	(2 credit	hours per	week)		
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)	
(course components and overall)	Lecture Quantitative Analysis of Software Architectures	3	28	42	20	
	Exercises Quantitative Analysis of Software	3	28	42	20	
	Architectures					
	Total workload	6	56	84	40	
Academic requirements and	Coursework: Regular and successful participation in the	exercises.	Participat	ion in the e	exercises is	
examinations	deemed successful when all of the exercises have been co	ompleted,	at least 50	) % have b	een solved	
	correctly, and at least one solution has been presented. A	ny change	es to the c	riteria mus	st be	
	announced prior to module registration.					
	Exam(s): Joint examination for all module courses; gener	ally, an or	al examina	ation in the	e teaching	
	language. Alternatively, a written examination (lasting 9	0 minutes	s) is possib	le. The exa	imination	
	type(s) will be announced prior to module registration.					
	Grades will be awarded for the module examination(s).					
Module duration	l semester					
Semester(s) offered	Summer semester, offered occasionally					
Literature	L. Bass, P. Clemens, R. Kazman: Software Architecture in F	Practice, Fo	ourth Editi	on. Addisc	on Wesley,	
	V. Cortellessa, A. Di Marco, P. Inverardi: Model-Based Soft	ware Perf	ormance A	nalysis. Sp	pringer, 2014.	
	K. S. Irivedi, A. Bobbio: Reliability and Availability Enginee	ering: Mo	aeling, An	alysis, and	Applications.	
	Cambridge University Press, 2017.					
	S. Kounev, KD. Lange, J. von Kistowski: Systems Benchma	arking: Fo	r Scientist	s and Engi	neers,	
	Springer, 2021.					

Module title	Research Methods					
Module number/code	InfM-RM					
Module applicability, type and curricular area	M.Sc. Intelligent Adaptive Systems: Required modules					
Prerequisites	Mandatory: none					
	Recommended: none					
Module coordinator(s)	Wermter					
Teaching staff	Wermter, N.N.					
Language	English with teaching materials in English					
Qualification targets	<ul> <li>Students have an in-depth understanding of scientific methods and their applications in the fields of informatics and artificial intelligence: <ul> <li>They are familiar with the basic principles of scientific research.</li> <li>They can define and conduct experiments.</li> <li>They are able to test hypotheses and perform statistical evaluations on these.</li> </ul> </li> </ul>					
Contents	Students are introduced to scientific processes – from design of the experiment through its execution to data analysis and publication. Methods and tools used particularly in the fields of informatics and artificial intelligence are discussed. The topics covered include various types of empirical studies and their range of uses, statistical methods for data analysis, and scholarly publication and discourse. The interactive lecture is complemented by a mix of a seminar and a practical course during which students can gain practical experience in the concepts taught. Students conduct their own experiments and analyze and discuss the data collected to reinforce					
Course components and teaching	Lecture Research Methods (2 credit hours per week)					
format(s)	Exercises/Seminar Research Methods (2 credit hours per	week)				
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)	
(course components and overall)	Lecture Research Methods	3	28	42	20	
	Exercises/Seminar Research Methods	3	28	42	20	
	Total workload	6	56	84	40	
Academic requirements and examinations	Coursework: Regular and successful participation in the s in the teaching language).	seminar (s	seminar w	ork and a	presentation	
	Exam(s): Generally, an oral examination in the teaching la	anguage ( avaminati	on all of t	he content	t covered	
	type(s) will be announced prior to module registration.					
	Grades will be awarded for the module examination(s).					
Module duration	1 semester					
Semester(s) offered	Winter semester, every year					
Literature	Paul R. Cohen. Empirical methods for artificial intelligence M. Law and W.D. Kelton, editors. Simulation Modelling ar S. M. Ross. Introduction to Probability Models. Harcourt,	e, MIT Pre nd Analysi 7th editio	ess, Cambi s. McGrav n, 2000.	ridge, Mas w–⊡Hill Ed	s. 1995 ucation, 2000.	

Module title	Robot Technology				
Module number/code	InfM-RT				
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Human-Co	mputer Ir	iteraction	: Selection	
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced 1	opics in D	ata Scien	ce and Arti	ficial
	Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics				
	M.Sc. Intelligent Adaptive Systems: Required elective are	а			
Prerequisites	Mandatory: none				
	Recommended: Basic knowledge of knowledge processir	ıg			
Module coordinator(s)	Zhang				
Teaching staff	Zhang, N.N.				
Language	German or English with teaching materials in German or	English			
Qualification targets	Students master the mathematical tools for describing re	obotic syst	tems. The	y are able	to apply and
_	develop components for real robots.				
Contents	Practice-oriented mathematical tools for the description	of robotic	systems	are explair	ed. Methods
	for generating trajectories/paths for different types of ro	bots such	as robot a	arms, mobi	le and
	humanoid robots are taught. The basics of control theory	/ are also i	ntroduce	d. The theo	oretical
	knowledge is reinforced with practical exercises.				
Course components and teaching	Lecture Robot Technology (2 credit hours per week)				
format(s)	Exercises Robot Technology (1 credit hour per week)				
	Practical Course Robot Practical Course (1 credit hour per	week)			
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)
(course components and overall)	Lecture Robot Technology	3	28	42	20
	Exercises Robot Technology	2	14	36	10
	Practical Course Robot Practical Course	1	14	14	2
	Total workload	6	56	92	32
Academic requirements and	Coursework: Regular and successful participation in the	exercises a	and practi	cal course.	Participation
examinations	in the exercises is deemed successful if all tasks have bee	n complet	ted and at	t least 50 %	have been
	solved correctly. Successful participation in the practical	course req	uires regu	ular attend	ance,
	continuous participation, and successful collaboration. A	ny change	es will be a	announced	l prior to
	module registration.				
	Exam(s): Generally, an oral examination in the teaching I	anguage (	on all of t	he content	t covered
	during the lecture, exercises, and practical course). Alterr	natively, a	written e	xaminatio	n is possible.
	The examination type(s) will be announced prior to mod	ule registr	ation.		
	Grades will be awarded for the module examination(s).				
Module duration	1 semester				
Semester(s) offered	Summer semester, every year				
Literature					

Module title	Speech Signal Processing						
Module number/code	InfM-SSV						
Module applicability, type and	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Selection						
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial						
	Intelligence und Domain Knowledge in Data Science and	Artificial I	Intelligend	ce: Informa	atics		
	M.Sc. IT Management and Consulting: Required elective	area — IT d	levelopme	ent			
	M.Sc. Intelligent Adaptive Systems: Required elective are	а					
Prerequisites	Mandatory: none	Mandatory: none					
	Recommended: Basic knowledge in signal processing						
Module coordinator(s)	Gerkmann						
Teaching staff	Gerkmann, N.N.						
Language	German or English with teaching materials in English						
Qualification targets	Students can explain the basics of speech production, pe	rception, a	and analy:	sis; unders	tand the		
	mathematical and information theoretic foundations of	speech sig	nal proce	ssing; and	apply the		
	methods learned and explain the functions of practical s	peech sigr	nal proces	sing syster	ms.		
Contents	Language is probably the most natural and important me	ethod of ir	nterpersor	nal commı	unication.		
	However, voice commands are also becoming increasing	y importa	nt in hum	ian-machii	ne interaction.		
	Speech communication devices such as smartphones, he	aring aids	, and voice	e-controlle	ed assistants		
	enable or simplify communication by means of modern s	ignal prod	cessing co	ncepts. In	this lecture,		
	students learn about basic speech signal processing conc	epts used	in smartp	phones, as	sistive		
	listening devices, and voice-controlled assistants. In parti	cular, the	module lo	ooks at the	following:		
	<ul> <li>signal-related fundamentals of speech generation</li> </ul>						
	<ul> <li>speech perception</li> </ul>						
	<ul> <li>speech analysis</li> </ul>						
	speech enhancement						
	<ul> <li>speech coding (speech compression)</li> </ul>						
Course components and teaching	Lecture Speech Signal Processing (2 credit hours per week	()					
format(s)	Exercises Speech Signal Processing (2 credit hours per we	ek)					
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Speech Signal Processing	3	28	42	20		
,	Exercises Speech Signal Processing	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the	exercises.	Any chan	ges to the	criteria must		
examinations	be announced prior to module registration.		,	0			
	Exam(s): Joint examination for all module courses; gener	ally, an or	al examin	ation in th	e teaching		
	language. Alternatively, a written examination is possible	e. The exa	mination	type(s) wi	ll be		
	announced prior to module registration.			<i>y</i> ,			
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Summer semester, every year						
Literature	P. Vary, R. Martin: Digital Speech Transmission, Wiley 200	6.					
	V. Pulkki, M. Karjalainen, Communication Acoustics, Wile	y 2015.					
	J. Benesty, M.M. Sondhi, Y. Huang (Eds.): Handbook of Spe	eech Proce	essing, Spi	ringer, 200	8.		
	R.C. Hendriks, T. Gerkmann, J. Jensen, "DFT-Domain Based	d Single-N	licrophon	e Noise Re	duction for		
	Speech Enhancement – A Survey of the State of the Art",	Synthesis	Lectures of	on Speech	and Audio		
	Processing, Morgan & Claypool Publishers, pp. 1-80, Jan 2	013.		•			

Module title	Software Architecture						
Module number/code	InfM-SWA						
Module applicability, type and curricular area	<ul> <li>M.Sc. Informatics: Advanced modules / Focus Software Engineering: Selection</li> <li>M.Sc. Data Science and Artificial Intelligence: Required elective area – Fundamentals of Data Science and Artificial Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics</li> <li>M.Sc. IT Management and Consulting: Required elective area – IT development</li> <li>M.Sc. Information Systems: Required elective area – Informatics und Specialization – Development and Management of Information Systems</li> <li>M.Sc. Intelligent Adaptive Systems: Required modules</li> </ul>						
Prerequisites	Mandatory: none						
	Recommended: Programming skills in an object-oriented	program	ming lang	uage			
Module coordinator(s)	Professur Softwaretechnik						
leaching staff	Professur Softwaretechnik, van Hoorn, N.N.						
Language	English with teaching materials in English or German wit possibly in English	h teachin	g materia	ls in Germa	an and		
Qualification targets	Students have a sound understanding of the requirements for software architecture as a component in the development of complex systems. They possess fundamental knowledge of the methods, principles, techniques, and procedures involved in the development of software architectures.						
Contents	<ul> <li>Students take a closer look at software design in the large, whereby the following topics are covered in greater depth and relevant literature and practical experience are also taken into account: <ul> <li>Introduction to software architecture (relevance, basic terminology and concepts)</li> <li>Brief introduction into requirements engineering and its relationship to software architecture</li> <li>The role of the person responsible for software architecture</li> <li>Methods and procedures for architecture design</li> <li>Specification, modeling and documentation of software architectures</li> <li>Architecture guidelines and principles</li> <li>Architecture patterns and styles</li> <li>Variability and product line architectures</li> <li>Architecture evaluation, quality assurance, architecture optimization</li> <li>Cloud-native architectural styles such as microservices and serverless</li> </ul> </li> </ul>						
Course components and teaching	Lecture Software Architecture (2 credit hours per week)						
format(s)	Seminar Architecture-centric Software Development (2 cr	edit hour	s per weel	()	<i>(</i>		
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Software Architecture	3	28	22	40		
	Seminar Architecture-centric Software Development	3	28	30	32		
	Iotal workload	6	. 56	52	12		
examinations	the teaching language). Any changes to the criteria must	be annou	eminar w inced prio	ork and pre r to module	esentation in eregistration.		
	Exam(s): Joint examination for all module courses, generally a written examination (duration 90 minutes) in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration. Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Winter semester, every year						
Literature	L. Bass, P. Clemens, R. Kazman: Software Architecture in P R. Taylor, N. Medvidovic, E. Dashofy. Software Architecture R. Reussner, W. Hasselbring. Handbuch der Software-Arch Further topic-specific literature will be mentioned in the	Practice, 4 <sup>1</sup> e: Founda nitektur. 2 course.	<sup>th</sup> edition. Itions, The I <sup>nd</sup> edition,	Addison W ory, and Pr , dpunkt, 2	/esley, 2021. actice. 2009. 008.		

Module title	User Interface Software and Technology						
Module number/code	InfM-UIST						
Module applicability, type and curricular area	M.Sc. Informatics: Advanced modules / Focus Human-Computer Interaction: Required for focus M.Sc. IT Management and Consulting: Required elective area – IT development M.Sc. Intelligent Adaptive Systems: Required elective area						
Prerequisites	Mandatory: none						
	Recommended: Kenntnisse im Bereich Mensch-Compute	r-Interakt	ion und Ir	nteraktion	sdesign		
Module coordinator(s)	Steinicke						
Teaching staff	Steinicke, N.N.						
Language	English with teaching materials in English or German wit German	h teachin	g materia	ls in Englis	h and/or		
Qualification targets	Students understand how various software and hardware	e compon	ents of in	teractive u	ser interfaces		
	work and learn about their potential and limitations. The	y are able	e to furthe	r their the	oretical		
	knowledge through practical application on small prototy in the process. Students are moreover able to evaluate th	ypes and e ese syster	examine n ms.	iew intera	ction concepts		
Contents	Students are familiarized with various software and hardware components of user interfaces (UIs), for example, from the fields of traditional graphical UIs (GUIs), web UIs, tangible UIs, and virtual and augmented reality 3D UIs as well as multimedia, new input and output devices, and computer-supported cooperative work. In the lectures, components of interactive user interfaces will be introduced, and their potential and limitations will be discussed. Smaller prototypes are developed during the exercises based on the software and hardware components. These prototypes are used to develop novel interaction concepts, which are then examined and evaluated during smaller nilot studies.						
Course components and teaching	Lecture User Interface Software and Technology (2 credit	hours per	week)				
format(s)	Exercises User Interface Software and Technology (2 credi	it hours pe	er week)				
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture User Interface Software and Technology	3	28	42	20		
	Exercises User Interface Software and Technology	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and examinations	Coursework: Regular and successful participation in the exercises. Any changes to the criteria must be announced prior to module registration. Exam(s): Generally, a written examination (60 minutes) in the teaching language. Alternatively, an oral examination may be possible. The examination type(s) will be announced prior to module registration. Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Winter semester, every year						
Literature	Proceedings of the Annual Symposium on User Interface J.D. Foley, A. van Dam, S.K. Feiner: Computer Graphics – P	Software riciples ar	and Techr nd Practice	ology, ACI e, Addison	N Wesley		

Module title	Knowledge Processing						
Module number/code	InfM-WV						
Module applicability, type and	M.Sc. Informatics: Advanced modules						
curricular area	M.Sc. Data Science and Artificial Intelligence: Advanced T	M.Sc. Data Science and Artificial Intelligence: Advanced Topics in Data Science and Artificial					
	Intelligence und Domain Knowledge in Data Science and	Intelligence und Domain Knowledge in Data Science and Artificial Intelligence: Informatics					
	M.Sc. Information Systems: Required elective area – Infor	matics					
	M.Sc. Bioinformatics: Required elective area – informatics	s und Req	uired elec	tive area –	life sciences,		
	informatics, and bioinformatics						
	M.Sc. Intelligent Adaptive Systems: Required elective area	N.Sc. Intelligent Adaptive Systems: Required elective area					
Prerequisites	Mandatory: none						
	Recommended: Basic knowledge of knowledge processin	ig and log	ic				
Module coordinator(s)	Wermter						
Teaching staff	Wermter, N.N.						
Language	German with teaching materials in German and possibly	in English	n or Englis	h with tea	ching		
	materials in English						
Qualification targets	Student have an in-depth understanding of how to hand	le data, in	formatior	n, and know	wledge for		
	complex domains. They are able to analyze requirements	and to se	elect suita	ble, i.e. ad	equate and		
	efficient, knowledge processing concepts. Moreover, they	can com	orehend co	omplex pro	oblems and		
	develop adequate solutions in the field of intelligent syst	ems.					
Contents	Students focus on advanced methods and concepts for kr	nowledge	presentat	ion and pr	ocessing:		
	description logics, ontologies, non-deductive reasoning, E	Bayesian r	networks,	machine p	lanning,		
	hybrid knowledge processing, knowledge-based agents, and knowledge processing in multi-agent						
	systems.						
Course components and teaching	Lecture Knowledge Processing (2 credit hours per week)						
format(s)	Seminar Knowledge Processing (2 credit hours per week)						
	Alternatively, teaching format may be lecture with 3 cred	it hours p	er week a	nd semina	r		
	with 1 credit hour per week.						
Workload		Credits	P (hrs)	S (hrs)	EP (hrs)		
(course components and overall)	Lecture Knowledge Processing	3	28	42	20		
	Seminar Knowledge Processing	3	28	42	20		
	Total workload	6	56	84	40		
Academic requirements and	Coursework: Regular and successful participation in the s	seminar (s	seminar w	ork and a	presentation		
examinations	in the teaching language).						
	Exam(s): Generally, an oral examination in the teaching la	anguage (	on all of t	he content	covered		
	during the lecture and seminar). Alternatively, a written e	examinati	on is poss	ible. The e	xamination		
	type(s) will be announced prior to module registration.						
	Grades will be awarded for the module examination(s).						
Module duration	1 semester						
Semester(s) offered	Winter semester, every year						
Literature							