Module Handbook

for the

Master Programme "Computer Science"

at

Rheinischen Friedrich-Wilhelms-Universität Bonn

revised version: September 23, 2022

The curriculum of the master programme is divided into four sub-curricula, each corresponding to one of the four main areas of competence in research of the Bonn Institute of Computer Science:

- 1. Algorithmics
- 2. Graphics, Vision, Audio
- 3. Information and Communication Management
- 4. Intelligent Systems

Module numbers **MA-INF ASXY** have been assigned according to the following key: vergeben:

- \bullet **A** = number of the area of competence
- $\mathbf{S} = \text{semester within the master curriculum}$
- XY = sequential number within the semester and the respective area of competence (two digits)

According to the curriculum, all modules ought to be taken between the first and the third semester. The fourth semester is reserved for preparing the master thesis.

Contents

1	Algorithmics	2
2	Graphics, Vision, Audio	36
3	Information and Communication Management	65
4	Intelligent Systems	90
5	Master Thesis	136

1 Algorithmics

MA-INF 1102	L4E2	9 CP	Combinatorial Optimization	. 3
MA-INF 1103	L4E2	9 CP	Cryptography	
MA-INF 1105	L2E2	6 CP	Algorithms for Data Analysis	. 5
MA-INF 1106	L2	4 CP	HPC modern Architectures and Trends	. 6
MA-INF 1107	L2E2	6 CP	Foundations of Quantum Computing	. 7
MA-INF 1201	L4E2	9 CP	Approximation Algorithms	. 8
MA-INF 1202	L4E2	9 CP	Chip Design	. 9
MA-INF 1203	L4E2	9 CP	Discrete and Computational Geometry	10
MA-INF 1205		6 CP	Graduate Seminar Discrete Optimization	11
MA-INF 1206	Sem2	4 CP	Seminar Randomized and Approximation Algorithms	12
MA-INF 1207	Lab4	9 CP	Lab Combinatorial Algorithms	13
MA-INF 1209	Sem2	4 CP	Seminar Advanced Topics in Cryptography	14
MA-INF 1213	L4E2	9 CP	Randomized Algorithms and Probabilistic Analysis	15
MA-INF 1217	Sem2	4 CP	Seminar Theoretical Foundations of Data Science	16
MA-INF 1218	L4E2	9 CP	Algorithms and Uncertainty	
MA-INF 1219	Sem2	4 CP	Seminar Algorithmic Game Theory	18
MA-INF 1220	Sem2	4 CP	Seminar Algorithms for Computational Analytics	19
MA-INF 1221	Lab4	9 CP	Lab Computational Analytics	20
MA-INF 1222	Lab4	9 CP	Lab High Performance Optimization	21
MA-INF 1223	L4E2	9 CP	Privacy Enhancing Technologies	22
MA-INF 1301	L4E2	9 CP	Algorithmic Game Theory	23
MA-INF 1304	Sem2	4 CP	Seminar Computational Geometry	24
MA-INF 1305		6 CP	Graduate Seminar on Applied Combinatorial	
			Optimization	25
MA-INF 1307	Sem2	4 CP	Seminar Advanced Algorithms	
MA-INF 1308	Lab4	9 CP	1 0	27
MA-INF 1309	Lab4	9 CP	Lab Efficient Algorithms: Design, Analysis and	
			Implementation	28
MA-INF 1314	L4E2	9 CP	Online Motion Planning	29
MA-INF 1315	Lab4	9 CP	Lab Computational Geometry	30
MA-INF 1316	Lab4	9 CP	Lab Cryptography	
MA-INF 1320		9 CP	Lab Advanced Algorithms	
MA-INF 1321		6 CP	Binary Linear and Quadratic Optimization	
MA-INF 1322		4 CP	Seminar Focus Topics in High Performance Computing .	
MA-INF 1323	L4E2	9 CP	Computational Topology	35

Module	Combinatorial Optimization								
MA-INF 1102									
Workload	Credit points	Duration	Frequency						
270 h	9 CP	1 semester	at leas	st every y	ear				
Module	Prof. Dr. Jens	s Vygen							
coordinator									
Lecturer(s)	All lecturers o	f Discrete M	athemati	.cs					
Classification	Programme		Mode	Seme	ster				
Classification	M. Sc. Compu	iter Science	Option	al 1. or	2.				
Technical skills	Advanced know	wledge of co	mbinator	ial optimi	ization. Modelli	ng			
	and developme	ent of solution	n strateg	gies for co	mbinatorial				
	optimization p	$_{ m roblems}$							
Soft skills	Mathematical	_	•	-	,				
		thinking, presentation of solutions to exercises							
Contents	Matchings, b-1	Matchings, b-matchings and T-joins, optimization over							
	matroids, sub	nodular fund	tion min	imization	, travelling				
	salesman prob	lem, polyhed	lral comb	inatorics,	NP-hard probl	ems			
Prerequisites	none								
	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP			
Format	Lecture			4	60 T / 105 S	5.5			
	Exercises			2	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching;	S = inde	pendent s	study				
Exam achievements	Oral exam				(gra	ded)			
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)			
Forms of media									
	• B. Korte, J.	Vygen: Con	binatoria	al Optimi	zation: Theory	and			
	Algorithms. Springer, 6th edition, 2018								
	• A. Schrijver: Combinatorial Optimization: Polyhedra and								
Literature	Efficiency. Springer, 2003								
Literature	• W. Cook, W	. Cunningha	ım, W. P	ulleyblan	k, A. Schrijver:				
	Combinatorial	_	-						
	• A. Frank: C	onnections in	ı Combir	natorial O	ptimization. Ox	xford			
	University Press, 2011								

Module MA-INF 1103	Cryptography									
Workload	Credit points Duration Frequency									
270 h	9 CP	1 semeste								
Module	Dr. Michael N		3.323	J						
coordinator	21. PHOLOGIA TUDION									
Lecturer(s)	Dr. Michael N	üsken								
	Programme		Mode	Seme	ster					
Classification	M. Sc. Compu	ter Science	Option	al 1. or	2.					
Technical skills	interplay betw	Understanding of security concerns and measures, and of the interplay between computing power and security requirements. Mastery of the basic techniques for cryptosystems and								
Soft skills	Oral presentation (in tutorial groups), written presentation (of exercise solutions), team collaboration in solving homework problems, critical assessment									
Contents	_				ms: AES, RSA,					
		· ·		· ·	nge, cryptograp					
		, –		,	toring integers a	and				
	discrete logari	thms; lower	bounds 1	n structur	red models.					
Prerequisites	none			.,.						
	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP				
Format	Lecture			4	60 T / 105 S	5.5				
	Exercises			2	30 T / 75 S	3.5				
	T = face-to-fa	ce teaching;	S = inde	ependent s	study					
Exam achievements	Written exam				(gra	ded)				
Study achievements	Successful exe	rcise partici	oation		(not gra	ded)				
Forms of media										
Literature	Jonathan KaModern CryptCourse notes	ography, Cl		(2015/20	08). Introduction	on to				

Module MA-INF 1105	Algorithms	for Data	Analysis	1					
Workload	Credit points	Duration	Freque	nev					
180 h	6 CP	$\frac{1}{1}$ semeste	_	t every 2 j	vears				
Module			at Icas	CVCIY 2,	years				
coordinator	Prof. Dr. Petra Mutzel								
Lecturer(s)	Prof. Dr. Petr	n Mutzol							
Lecturer(s)		a wiutzei	Mode	Semes	.				
Classification	Programme	tan Caianaa							
T 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	M. Sc. Compu		_			1			
Technical skills					chniques of mod	iern			
					analytics tasks				
Soft skills				ds, critica	d discussion of				
	applied metho		_						
Contents					ructures relevai				
	analytic tasks	for big data	a, i.e., algo	rithms for	graph similari	ity,			
	parallel algorit	thms, I/O -d	lata structi	ires, and	streaming				
	algorithms.								
Prerequisites	Required:								
	none								
	Recommended	:							
			f foundation	ns of algo	orithms and da	ta			
	structures is e	_	1 TO GIT GOVIE	.113 01 01-80					
	Teaching forms	at C	Group size	h/week	Workload[h]	CP			
Format	Lecture			2	30 T / 45 S	2.5			
	Exercises			2	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching	S = inder	endent st		ı			
Exam achievements	Oral exam					ded)			
Study achievements	Successful exe	rcise partici	pation		(not gra	ded)			
Forms of media						-			
Literature									

26.1.1	HPC modern Architectures and Trends									
Module MA-INF 1106	HPC modern Architectures and Trends									
Workload	Credit points Duration Frequency									
120 h	4 CP 1 semester every year									
Module	Prof. Dr. Estela Suarez									
coordinator	1 101. D1. ESTEIA SUAITEZ									
Lecturer(s)	Prof. Dr. Estela Suarez									
. ,	Programme Mode Semester									
Classification	M. Sc. Computer Science Optional 1-3.									
Technical skills	Understanding principles of computer architecture of modern									
	HPC systems at component (processor, accelerators) and system									
	level (system architecture, network, memory hierarchy) and									
	their implication for application programming.									
Soft skills	Ability to select an specific HPC topic and present it in a clear									
	and comprehensive manner suitable for a lightning talk (10min)									
Contents	Computer architectures, system components (CPU, memory,									
	network) and their interrelation.									
	Software environment									
	Parallel architectures and parallel programming paradigms									
	(MPI, OpenMP, CUDA)									
	High Performance Computing									
	Current challenges									
Prerequisites	Required:									
	Knowledge of a modern programming language (like C, C++, Python,?).									
	Interest in High Performance Computing									
	Recommended:									
	Bachelor Lecture "Computerarchitektur"									
E 4	Teaching format Group size h/week Workload[h] CP									
Format	Lecture 2 30 T / 90 S 4									
	T = face-to-face teaching; S = independent study									
Exam achievements	Oral exam (graded)									
Study achievements	none (not graded)									
Forms of media										
	- John L. Hennessy, David A. Patterson: Computer Architecture									
	- A Quantitative Approach. Morgan Kaufmann Publishers, 2012									
	- David A. Patterson, John L. Hennessy: Computer									
	Organization and Design - The Hardware / Software Interface.									
Literature	Morgan Kaufmann Publishers, 2013									
	- Message Passing Interface Forum: MPI: A Message-Passing									
	Interface Standard, Version 3.1									
	- OpenMP Application Programming Interface, Version 4.5,									
	November 2015									

Module MA-INF 1107	Foundations of Quantum Computing									
Workload	Credit points	Credit points Duration Frequency								
180 h	6 CP	1 semes	ster	every y	ear					
Module	Prof. Dr. Chr.	istian Baı	uckh	age						
coordinator										
Lecturer(s)	Prof. Dr. Chr.	istian Baı	uckh	age						
Classification	Programme			Mode	Semest	ter				
Classification	M. Sc. Compu	iter Scien	ce	Optiona	l 1. or 3	3.				
Technical skills			•							
Soft skills										
Contents										
Prerequisites	none									
	Teaching forms	at	Gr	oup size	h/week	Workload[h]	CP			
Format	Lecture				2	30 T / 45 S	2.5			
	Exercises				2	30 T / 75 S	3.5			
	T = face-to-fa	ce teachir	ng; S	S = indep	endent st	udy				
Exam achievements	Schriftliche Pr	Schriftliche Prüfung (graded)								
Study achievements	Erfolgreiche Ü	bungsteil	nahi	ne		(not gra	ded)			
Forms of media										
Literature										

Module	Approximat	tion Algori	$\overline{ ext{thms}}$							
MA-INF 1201										
Workload	Credit points	Duration	Freque	ency						
270 h	9 CP	9 CP 1 semester at least every year								
Module	Prof. Dr. Jens Vygen									
coordinator		v O								
Lecturer(s)	All lecturers o	All lecturers of Discrete Mathematics,								
	Senior Prof. D	r. Marek Ka	rpinski							
CI 10 II	Programme		Mode	Seme	ster					
Classification	M. Sc. Compu	ter Science	Option	al 2. or	3.					
Technical skills	Introduction t	o design and	analysis	of most i	important					
	approximation	algorithms	or NP-h	ard comb	inatorial					
	optimization p	oroblems, and	l various	techniqu	es for proving lower					
	and upper bou	ınds, probabi	listic me	thods and	d applications					
Soft skills	Presentation o	f solutions a	nd metho	ods, critic	al discussion of					
	applied metho	ds and techn	iques							
Contents	Approximation	n Algorithms	and Ap	proximati	on Schemes. Design					
	and Analysis of	of Approxima	tion algo	orithms fo	or selected NP-hard					
	problems, like	Set-Cover, a	nd Verte	x-Cover p	oroblems,					
	MAXSAT, TS	P, Knapsack	Bin Pac	cking, Ne	twork Design,					
	Facility Locati	on. Introduc	tion to v	arious ap	proximation					
	techniques (lik									
	Search, randor		_							
	MCMC-Metho	* *			nalysis of					
	approximation	hardness an	d PCP-S	Systems.						
Prerequisites	Recommended									
	Introductory k			ons of alg	gorithms and					
	complexity the									
	Teaching forms	at Gro	up size	h/week	Workload[h] CP					
Format	Lecture			4	60 T / 105 S 5.5					
	Exercises			2	30 T / 75 S 3.5					
	T = face-to-fa	ce teaching;	S = inde	pendent s	study					
Exam achievements	Oral exam				(graded)					
Study achievements	Successful exe	rcise particip	ation		(not graded)					
Forms of media										
	• S. Arora, C.	Lund: Hard	ness of A	pproxima	ations. In:					
	Approximation	n Algorithms	for NP-	Hard Pro	blems (D. S.					
	Hochbaum, ed.), PWS, 1996									
	• M. Karpinski: Randomisierte und approximative Algorithmen									
	für harte Berechnungsprobleme, Lecture Notes (5th edition),									
Literature	Universität Bonn, 2007									
	· ·			_	zation: Theory and					
	Algorithms (6t				-					
					s, Springer, 2001					
	• D. P. Willian									
	Approximation Algorithms, Cambridge University Press, 2011									

Module MA-INF 1202	Chip Design	1							
Workload	Credit points	Duration	Freque	ency					
270 h	9 CP	9 CP 1 semester every year							
Module	Prof. Dr. Jens Vygen								
coordinator									
Lecturer(s)	All lecturers o	f Discrete Ma	athemati	cs					
Classification	Programme		\mathbf{Mode}	Seme	ster				
Classification	M. Sc. Compu								
Technical skills	Knowledge of	the central p	roblems	and algor	ithms in chip				
	_		_		gorithms for so	_			
	_	,	_		hnical constraii				
	_	_	impleme	ent efficier	nt algorithms for	or			
	very large inst								
Soft skills		_	-		ng in chip desig	gn,			
	development o	_	,		thinking,				
	presentation o								
Contents	Problem form		_	_	0 , 0				
	synthesis, plac	ement, routii	ng, timin	g analysi	s and optimiza	tion			
Prerequisites	none				T				
	Teaching forma	at Gro	up size	h/week		CP			
Format	Lecture			4	60 T / 105 S	5.5			
	Exercises			2	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching;	S = inde	pendent s	study				
Exam achievements	Oral exam				(gra	aded)			
Study achievements	Successful exer	rcise particip	ation		(not gra	aded)			
Forms of media									
		,	_		The Handbook				
	Algorithms for VLSI Physical Design Automation. CRC Press,								
	New York, 2008.								
	• S. Held, B. Korte, D. Rautenbach, J. Vygen: Combinatorial								
	optimization in VLSI design. In: "Combinatorial Optimization:								
Literature	Methods and Applications" (V. Chvátal, ed.), IOS Press,								
Divortabaro	Amsterdam 20								
	· ·		Design. I	Lecture N	otes (distribute	ed			
	during the cou	,	a	_	~ - ~	_			
					.K. Scheffer, ed				
		0			nentation, Circu				
	Design, and Process Technology. CRC Press, 2nd edition, 2016								

Module	Discrete an	d Comput	ational (Geome	try						
MA-INF 1203											
Workload	Credit points	Duration	Freque	-							
270 h	9 CP	1 semester	every y	ear							
Module	Prof. Dr. Ann	ne Driemel									
coordinator											
Lecturer(s)		Prof. Dr. Anne Driemel, PD Dr. Elmar Langetepe,									
		Dr. Herman Haverkort									
Classification	Programme		Mode	Seme	ster						
	M. Sc. Compu		Optiona								
Technical skills					acepts in the are						
		-		, ,	and analysis of						
				-	of the complex	ity					
	of geometric c	_			owledge						
	autonomously										
Soft skills	Social compet	`		-	_						
	solutions, goal			/	,						
	competence (a	. ,	, -	, ,							
	`	commitment	and willin	gness to	learn, creativity	y,					
	endurance).										
Contents			,	_	ms, hyperplane						
	arrangements, well-separated pair decomposition, spanners,										
	_				n, VC-dimension	n,					
	epsilon-nets, v	0 / 2		, –	٠,						
	randomized in			. –	tric distance						
	problems in di	mension two	and high	er.							
Prerequisites	Recommended										
	BA-INF 114 –		der algor	ithmisch							
	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP					
Format	Lecture			4	60 T / 105 S	5.5					
	Exercises			2	30 T / 75 S	3.5					
	T = face-to-fa	ce teaching;	S = indep	endent s	study						
Exam achievements	Oral exam					ded)					
Study achievements	Successful exe	rcise particip	ation		(not gra	$\frac{\widetilde{\mathrm{ded}}}{\mathrm{ded}}$					
Forms of media					, ,						
	• Jiri Matousek. Lectures on Discrete Geometry. Springer										
	Graduate Texts in Mathematics. ISBN 0-387-95374-4.										
	• Mark de Bei	rg, Otfried C	heong, Ma	arc van I	Kreveld, and Ma	ark					
	Overmars. Co	<u> </u>	٠,		,						
Literature	Applications (-		_							
	978-3-540-779		,	-							
	Narasimhan		netric Spa	nner Net	tworks						
	• Klein, Conci		_								

Module MA-INF 1205	Graduate S	eminar D	iscrete (Optimiz	ation			
Workload	Credit points	Duration	Freque	ency				
180 h	6 CP	1 semeste	r every	year				
Module	Prof. Dr. Jens	Prof. Dr. Jens Vygen						
coordinator								
Lecturer(s)	All lecturers o	f Discrete N	[athemati	ics				
Classification	Programme		Mode	Seme	ester			
Classification	M. Sc. Compu	iter Science	Option	al 2 .				
Technical skills	Competence to	o understan	d new res	earch res	ults based on			
	original literat	ure, to put	such resu	lts in a b	roader context a	and		
	present such re	present such results and relations.						
Soft skills	Ability to read	d and under	stand rese	earch pap	ers, abstract			
	thinking, prese	entation of	nathemat	ical resul	ts in a talk			
Contents	A current rese	arch topic i	n discrete	optimiza	tion will be cho	sen		
	each semester	and discuss	ed based	on origina	al literature.			
Prerequisites	Recommended	:						
	MA-INF 1102	– Combina	torial Opt	timization	1			
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
rormat	Seminar		10	4	60 T / 120 S	6		
	T = face-to-fa	ce teaching	S = inde	ependent	study			
Exam achievements	Oral presentat	ion, writter	report		(gra	ded)		
Study achievements					(not gra	ded)		
Forms of media								
Literature	The topics and the end of the			ıre will be	e announced tow	ards		

Module MA-INF 1206	Seminar Ra Algorithms	Seminar Randomized and Approximation Algorithms						
Workload	Credit points Duration Frequency							
120 h	4 CP	1 semest	_	•				
Module	Prof. Dr. Heik	o Röglin		<u>'</u>				
coordinator		J						
Lecturer(s)	Prof. Dr. Ann	e Driemel,	Prof. Dr.	Thomas K	Kesselheim,			
, ,	Prof. Dr. Heik	o Röglin, l	PD Dr. Elı	nar Lange	etepe,			
	Dr. Herman H	averkort, S	Senior Prof	. Dr. Mar	ek Karpinski			
C1 10 11	Programme	· · · · · · · · · · · · · · · · · · ·	Mode	Semes				
Classification	M. Sc. Compu	ter Science	Optiona	Optional 2.				
Technical skills	Ability to perfe	Ability to perform individual literature search, critical reading,						
	understanding,	and clear	presentati	on.				
Soft skills	Presentation of	f solutions	and method	ds, critica	d discussion of			
	applied method	ds and tecl	nniques					
Contents	Current topics	in design	and analys	is of rando	omized and			
	approximation	algorithm	s based on	lastest res	search literatur	e		
Prerequisites	none							
Format	Teaching forma	ıt (Group size	h/week	Workload[h]	CP		
rormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fac	ce teaching	S = inde	pendent st	udy			
Exam achievements	Oral presentati	ion, writte	n report		(gra	ded)		
Study achievements	(not graded)							
Forms of media								
Literature	The relevant li	terature w	ill be anno	unced in t	ime.			

Module	Lab Combin	Lab Combinatorial Algorithms						
MA-INF 1207								
Workload	Credit points	Duration	Freque	Frequency				
270 h	9 CP	1 semester	r every year					
Module	Prof. Dr. Jens Vygen							
coordinator								
Lecturer(s)	All lecturers o	f Discrete M	athemati	cs				
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optiona	al 2 .	2.			
Technical skills	Competence to	Competence to implement advanced combinatorial algorithms,						
	handling nontrivial data structures, testing, documentation.							
	Advanced software techniques.							
Soft skills	Efficient implementation of complex algorithms, abstract							
	thinking, documentation of source code							
Contents	Certain combi	Certain combinatorial algorithms will be chosen each semester.						
	The precise ta	sk will be ex	plained i	n a meeti	ng in the previo	ous		
	semester.							
Prerequisites	Recommended	:						
	MA-INF 1102	- Combinate	orial Opt	imization				
Format	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP		
Format	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching;	S = inde	pendent s	study			
Exam achievements	Oral presentat	ion, written	report		(gra	ded)		
Study achievements					(not gra	$\overline{\operatorname{ded}}$		
Forms of media								
Literature	The topics and the relevant literature will be announced towards							
Literature	the end of the	previous sen	nester					

Module	Seminar Advanced Topics in Cryptography								
MA-INF 1209									
Workload	Credit points	Duration	n	Frequer	ncy				
120 h	4 CP	1 semester every semester							
Module	Dr. Michael Nüsken								
coordinator									
Lecturer(s)	Dr. Michael N	Dr. Michael Nüsken							
Classification	Programme			Mode	Semest	ter			
Classification	M. Sc. Compu	iter Scienc	ce	Optional	2. or 3	3.			
Technical skills	Understanding	Understanding research publications, often written tersely.							
	Distilling this	into a pre	esent	ation. D	eterminat	tion of relevant	vs.		
	irrelevant material. Developing a presentation that fascinates fellow students.								
Soft skills	Understanding and presenting material both orally and in visual								
	_	media. Motivating other students to participate. Critical							
	assessment of	_			1 1				
Contents	A special topic	c within c	rypt	ography,	changing	from year to	year,		
	is studied in d	epth, base	ed or	n current	research	literature			
Prerequisites	Required:								
	MA-INF 1103	- Crypto	grap	hy					
	and one further	er course i	in cr	yptograp	hy like T	he Art of			
	Cryptography	or eSecur	ity.						
Format	Teaching forms	at	Gro	oup size	h/week	Workload[h]	CP		
rormat	Seminar			10	2	30 T / 90 S	4		
	T = face-to-fa	ce teachir	ng; S	= indep	endent st	udy			
Exam achievements	Oral presentat	ion, writt	en r	eport		(gra	ded)		
Study achievements						(not gra	ded		
Forms of media									
Literature	Current crypto	ographic l	itera	ture.		Current cryptographic literature.			

Module MA-INF 1213	Randomize	d Algorith	ms and	Probab	oilistic Analy	sis	
Workload	Credit points	Duration	Freque	encv			
270 h	9 CP	1 semester	_	every year			
Module	Prof. Dr. Heil		cvery	Jear			
coordinator	1 101. D1. 11011	ko 1togiiii					
Lecturer(s)	Prof. Dr. Heil	zo Röglin					
Lecturer (s)	Programme	ko 1togiiii	Mode	Seme	stor		
Classification	M. Sc. Compu	iter Science	Optiona				
Technical skills					the probabilisti	\overline{c}	
		orithms as w		•	gn and analysis		
Soft skills	Oral and write	<u> </u>	ion of so	lutions ar	nd methods.		
	abstract think	_			,		
Contents	Design and an	0	domized	algorithm	ıs		
	• complexity of			O			
			m walke				
	 Markov chains and random walks tail inequalities probabilistic method 						
	smoothed and	average-case	analysis	3			
	• simplex algo	rithm					
	• local search	_					
	• clustering al	gorithms					
	• combinatoria	-	-	ems			
	• multi-object	ive optimizat	ion				
Prerequisites	none						
	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral exam				(gra	ded)	
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)	
Forms of media							
	• lecture notes	5					
	• research arti	icles					
T:tonotuno	• Motwani, Ra	aghavan, Rar	domized	Algorith	ms, Cambridge		
Literature	University Pre						
	• Mitzenmach	er, Upfal, Pr	obability	and Con	nputing, Cambr	idge	
	University Pre	ess, 2nd editi	on, 2017				

Module MA-INF 1217	Seminar Theoretical Foundations of Data Science						
Workload	C	Duration	Th				
	Credit points		Frequency				
120 h	4 CP	1 semester	every ye	ear			
Module	Prof. Dr. Heil	Prof. Dr. Heiko Röglin					
coordinator							
Lecturer(s)	Prof. Dr. Ann	Prof. Dr. Anne Driemel, Prof. Dr. Thomas Kesselheim,					
	Prof. Dr. Heil	Prof. Dr. Heiko Röglin, PD Dr. Elmar Langetepe,					
	Dr. Herman H	Dr. Herman Haverkort					
CI IO II	Programme		Mode	Semester			
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	2. or 3.		
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	scientific papers.					
Soft skills	Ability to pres		ritically di	scuss the	se results in th	ie	
	framework of		-				
Contents	Current confer	rence and jou	ırnal pape	rs			
Prerequisites	none						
To 4	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 1218	Algorithms	and Unc	ertainty				
Workload	Credit points	Duration	Frequ	encv			
270 h	9 CP	1 semeste	_				
Module	Prof. Dr. Thomas Kesselheim						
coordinator							
Lecturer(s)	Prof. Dr. Tho	mas Kessel	neim				
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.		
Technical skills	Understanding	Understanding approaches for modeling uncertainty in					
	algorithmic th	algorithmic theory. Designing and analyzing algorithms with					
	performance g	performance guarantees in the context of uncertainty.					
Soft skills	Oral and written presentation of solutions and methods						
Contents	• Advanced O	Advanced Online Algorithms					
	Markov Dec:	isions Proc	esses				
	• Stochastic a	nd Robust	Optimizat	ion			
	Online Learn	ning Algori	hms and	Online Co	onvex Optimizat	tion	
Prerequisites	Recommended	:					
	Solid backgrou	ınd in algor	ithms, cal	lculus, and	d probability the	eory.	
	Specialized kn	owledge ab	out certai	n algorith	ms is not necess	sary.	
	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	S = inde	ependent s	study		
Exam achievements	Oral exam				(gra	ded)	
Study achievements	Successful exe	rcise partic	pation		(not gra	ded)	
Forms of media							
Literature	lecture notes,	research ar	icles				

Module MA-INF 1219	Seminar Al	Seminar Algorithmic Game Theory				
Workload	Credit points	Duration	Frequency			
120 h	4 CP 1 semester every year					
Module	Prof. Dr. Thomas Kesselheim					
coordinator						
Lecturer(s)	Prof. Dr. Tho	Prof. Dr. Thomas Kesselheim				
CI :C .:	Programme		Mode	Semest	ter	
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.	
Technical skills	Ability to understand new research results presented in original					
	scientific papers.					
Soft skills	Ability to perform individual literature search, critical reading,					
	and clear dida	and clear didactic presentation				
Contents	Advanced topi	ics in Algori	thmic Gam	e Theory	and Algorithi	mic
	Mechanism De	esign based	on current	conference	ce and journal	
	papers					
Prerequisites	none					
Format	Teaching forms	at C	roup size	h/week	Workload[h]	CP
Format	Seminar		10	2	30 T / 90 S	4
	T = face-to-fa	ce teaching	S = indep	endent st	udy	
Exam achievements	Oral presentat	tion, written	report		(gra	ded)
Study achievements					(not gra	ded)
Forms of media						
Literature						

Module	Seminar Algorithms for Computational Analytics						
MA-INF 1220							
Workload	Credit points	Duration	n Frequency				
120 h	4 CP	1 semester	at least	every ye	ar		
Module	Prof. Dr. Petra Mutzel						
coordinator							
Lecturer(s)	Prof. Dr. Petr	Prof. Dr. Petra Mutzel					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Computer Science		Optional	2. or 3	3.		
Technical skills	Ability to perf	Ability to perform individual literature search, critical reading,					
	understanding, and clear didactic presentation.						
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the					
	framework of	framework of the corresponding area.					
Contents	Current topics	in algorithr	ns for com	putationa	al analytics bas	sed	
	on recent resea	arch literatu	re.				
Prerequisites	Recommended	:					
	Interest in Alg	$ m_{corithms}$					
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = indep	endent st	tudy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	The relevant l	iterature wil	l be annou	nced in t	ime.		

Module MA-INF 1221	Lab Compu	itational A	nalytics	5			
Workload	Credit points	Duration	Freque	ncy			
270 h	9 CP	1 semester	1 -	•			
Module	Prof. Dr. Petra Mutzel						
coordinator							
Lecturer(s)	Prof. Dr. Peti	Prof. Dr. Petra Mutzel					
Classification	Programme		Mode	Seme	Semester		
Classification	M. Sc. Compu	iter Science	Optiona	d 2. or	3.		
Technical skills		0 /			cient algorithm	s for	
	_	computational analytics problems. The LAB also includes					
	_	experimental evaluation and documentation of the implemented					
	software.						
Soft skills		Ability to properly present and defend design decisions, to					
	prepare readal			,			
			_		nall teams over		
		,		siry ones	own results into	o tne	
<u> </u>	state-of-the-ar			imata ala	sanithmaa and da	+	
Contents	structures for			_	gorithms and da	ııa	
Prerequisites	Recommended		iai anaiyu	ics proble	:1115.		
Frerequisites	Interests in alg	· -					
	Teaching forms		oup size	h/week	Workload[h]	СР	
Format	Lab	at G1	8	4	60 T / 210 S	9	
			-		,		
	T = face-to-fa			pendent s		1 1\	
Exam achievements	Oral presentat	non, written	report		(0	ded)	
Study achievements					(not gra	iaea)	
Forms of media	/ml1		1 1	1 •	4:		
Literature	The relevant literature will be announced in time.						

Module MA-INF 1222	Lab High P	erforman	ce Opti	mization	1		
Workload	Credit points	Duration	Frequ	ency			
270 h	9 CP	1 semest	nester every year				
Module	Prof. Dr. Petr	Prof. Dr. Petra Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Petr	Prof. Dr. Petra Mutzel, Dr. Sven Mallach					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.		
Technical skills	Ability to desi	gn, analyze	and impl	ement alg	orithms for		
	computational analytics and optimization problems. The lab						
	also includes experimental evaluation and documentation of the						
	implemented software.						
Soft skills	Ability to properly present and defend design decisions, to						
	prepare readal	ole docume	ntation of	software;	skills in		
	constructively	collaborati	ng with o	thers in sr	nall teams over a		
	longer period	of time; ab	lity to cla	ssify ones	own results into the		
	state-of-the-ar	t of the res	p. area				
Contents							
Prerequisites	none						
Format	Teaching forms	at G	roup size	h/week	L J		
Format	Lab		8	4	60 T / 210 S 9		
	T = face-to-fa	ce teaching	S = inde	ependent s	study		
Exam achievements	Oral presentat	ion, writte	n report		(graded)		
Study achievements					(not graded)		
Forms of media							
Literature	The relevant la	iterature w	ill be anno	ounced in	time.		

Module	Privacy Enl	nancing Te	chnolo	gies				
MA-INF 1223	l IIVacy Lin	naneing re	cimolo	51CB				
Workload	Credit points	Duration	Freque	encv				
270 h	9 CP	1 semester	every	-				
Module	Dr. Michael N			J				
coordinator								
Lecturer(s)	Dr. Michael N	Tüsken						
	Programme		Mode	Semes	ster			
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.			
Technical skills	Knowledge: C	La contraction de la contracti			ncing privacy,			
	underlying sec	urity notions	, applica	tions and	restrictions.			
	Skills: Secure	Skills: Secure application of sophisticated cryptographic						
	schemes. Evaluation of their correctness, efficiency and security							
	in an application setting.							
Soft skills	Competences: Ability to assess schemes and their use in							
	_	applications. Critical assessment of applications.						
Contents	With more an	With more and more data available a clear separation of						
	sensitive data	is necessary	and need	ls to be p	rotected. Some	of		
	that data mus	t stay within	strict er	nvironmer	nts, for example	es		
	hospitals must	hospitals must store certain highly sensitive medical information						
	about patients but they are not allowed to store it outside its							
	own facilities. Some of that data is stored or collected in a cloud							
		environment in encrypted form, say data from a medical device						
	or a smart hor			_				
	_		*	-	o send immedia	te		
	help to a patie	_						
					of tension. The			
				ome high	ly sophisticated	_		
	tools for solving	ng the like pr	oblems.					
	• Fully homon	norphic encry	ption (F	THE).				
			, .	rticular:	Non-interactive	:		
	zero-knowledg							
	• Secure multi			` /				
	• Anonymisat:		-		_			
	• Weaker priva		ike diffe	rential pri	vacy.			
Prerequisites	Recommended			1-:1-1				
	Basic knowled			0 0		,		
	_		_		nelp. In particu			
					ing are importa	ant,		
	but also topics				•			
	mathematics, Teaching forms		up size	h/week	Workload[h]	СР		
Format	Lecture	Gro	up size	11/ week	60 T / 105 S	5.5		
10111100	Exercises			2	30 T / 75 S	3.5		
		eo topahina: (inda			1 3.0		
Even cabiarres	T = face-to-fa Schriftliche Pr		$\mathfrak{z} = \mathrm{mae}$	репаент 8		, deq.)		
Exam achievements	Erfolgreiche Ü		mo			ided)		
Study achievements Forms of media	Errorgreiche U	bungstellitäll	1116		(not gra	ided)		
Literature								
Literature								

Module	Algorithmic	Game T	neory					
MA-INF 1301								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	_	2 years				
Module	Prof. Dr. Tho	mas Kesselh						
coordinator								
Lecturer(s)	Prof. Dr. Tho	mas Kesselh	eim,					
` ,	Senior Prof. D							
~	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.			
Technical skills	Knowledge of	fundamenta	results i	n (algorit	hmic) game theory			
	and (algorithm	nic) mechani	sm desig	n. Techni	ques and methods			
	related to mat	hematical m	odeling o	of strategi	c agents. Analyzing			
	and designing	systems of s	trategic a	agents, wi	th a focus on			
	computational	efficiency a	nd perfor	mance gu	arantees.			
Soft skills	Presentation o	f solutions a	nd meth	ods, critic	al discussion of			
	applied metho	ds and tech	niques					
Contents	• basic game t	heory						
	• computabilit	y and hardr	ess of eq	uilibria				
	• convergence	of dynamics	of selfish	agents				
	• (bounds on t	• (bounds on the) loss of performance due to selfish behavior						
	• designing inc	• designing incentive-compatible auctions						
	• maximizing revenue							
	• designing me	ullet designing mechanisms for stable and fair allocations without						
	money							
Prerequisites	Recommended							
	Introductory k			ons of alg	gorithms and			
	complexity the							
	Teaching forms	at Gr	oup size	h/week	Workload[h] CP			
Format	Lecture			4	60 T / 105 S 5.5			
	Exercises			2	30 T / 75 S 3.5			
	T = face-to-fa	ce teaching;	S = inde	ependent s	study			
Exam achievements	Written exam				(graded)			
Study achievements	Successful exer	rcise particij	oation		(not graded)			
Forms of media								
	· ·				Vazirani (ed.):			
	Algorithmic Game Theory, Cambridge Univ. Press, 2007							
	• T. Roughgarden, Twenty Lectures on Algorithmic Game Theory, Cambridge Univ. Press, 2016							
					Tronnine Game			
	Theory, Camb	ridge Univ.	Press, 20	16				
Literature	Theory, Camb • A. Karlin, Y	ridge Univ. 7. Peres, Gar	Press, 20 ne Theor	16 y, Alive, <i>I</i>	AMS, 2017			
Literature	Theory, Camb • A. Karlin, Y • Y. Shoham,	ridge Univ. 7. Peres, Gar K. Leyton-F	Press, 20 ne Theor Brown, M	16 y, Alive, <i>I</i>	AMS, 2017			
Literature	Theory, Camb • A. Karlin, Y • Y. Shoham, Cambridge Un	ridge Univ. C. Peres, Gar K. Leyton-Faiv. Press, 20	Press, 20 ne Theor Brown, M 009	16 y, Alive, A ultiagent	AMS, 2017 Systems,			
Literature	Theory, Camb • A. Karlin, Y • Y. Shoham, Cambridge Un • D. M. Kreps	ridge Univ. f. Peres, Gar K. Leyton-H iv. Press, 20 : A Course	Press, 20 ne Theor Brown, M 009	16 y, Alive, A ultiagent	AMS, 2017			
Literature	Theory, Camb • A. Karlin, Y • Y. Shoham, Cambridge Un • D. M. Kreps Univ. Press, 1	ridge Univ. T. Peres, Gar K. Leyton-H T. Press, 20 T. A Course 1990	Press, 20 ne Theor Brown, M 009 in Micros	y, Alive, Aultiagent	AMS, 2017 Systems,			

Module	Seminar Computational Geometry						
MA-INF 1304							
Workload	Credit points	Duration		Frequency			
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Ann	e Driemel					
coordinator							
Lecturer(s)	Prof. Dr. Ann	Prof. Dr. Anne Driemel, PD Dr. Elmar Langetepe,					
	Dr. Herman Haverkort						
Classification	Programme		I	Mode	Semest	ter	
Classification	M. Sc. Compu	iter Scienc	e (Optional	2-4.		
Technical skills	To independen	To independently study problems at research level, based on					
	research publications, to prepare a concise summary, to present						
	the summary i	the summary in a scientific talk, to lead a critical discussion					
	with other sen	with other seminar participants.					
Soft skills							
Contents	Current topics	in compu	tatio	onal geor	netry.		
Prerequisites	Recommended	:					
	BA-INF 114 –	Grundlag	en d	ler algori	thmische	n Geometrie	
	MA-INF 1203	– Discrete	anc	d Compu	tational	Geometry	
TD 4	Teaching forms	at	Gro	up size	h/week	Workload[h]	CP
Format	Seminar			10	2	30 T / 90 S	4
	T = face-to-fa	ce teaching	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en re	port		(gra	ded)
Study achievements						(not gra	$\overline{\operatorname{ded}}$
Forms of media	Multimedia pr	Multimedia projector, black board.					
Literature	The relevant li	iterature w	rill b	e annou	nced.		

Module	Graduate Seminar on Applied Combinatorial						
MA-INF 1305	Optimization	n					
Workload	Credit points	Duration	Frequency				
180 h	6 CP	1 semester	emester every year				
Module	Prof. Dr. Jens	s Vygen					
coordinator							
Lecturer(s)	All lecturers o	f Discrete M	athematic	cs			
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 3.			
Technical skills	Competence to	Competence to understand new theoretical results and practical					
	solutions in V	LSI design a	nd related	d applicat	tions, as well as		
	presentation o	f such result	S				
Soft skills	Ability to read and understand research papers, abstract						
	thinking, presentation of mathematical results in a talk						
Contents	Current topics	in chip desi	gn and re	elated app	olications		
Prerequisites	Recommended	:					
	At least 1 of t	he following:					
	MA-INF 1102	- Combinat	orial Opt	imization			
	MA-INF 1202	- Chip Desi	gn				
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Format	Seminar		10	4	60 T / 120 S	6	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	The topics and the relevant literature will be announced towards						
Diterature	the end of the	the end of the previous semester					

Module MA-INF 1307	Seminar Ad	Seminar Advanced Algorithms				
Workload	Credit points	Duration	Freque	ncv		
120 h	4 CP 1 semester every year					
Module	Prof. Dr. Tho	mas Kessel				
coordinator						
Lecturer(s)	Prof. Dr. Ann	e Driemel,	Prof. Dr. '	Thomas K	Kesselheim,	
` '	Prof. Dr. Heil	ko Röglin, İ	D Dr. Eln	nar Lange	etepe,	
	Dr. Herman H			J	1 /	
CI 10 II	Programme		Mode	Semes	ter	
Classification	M. Sc. Computer Science Optional 3.					
Technical skills	Presentation of selected advanced topics in algorithm design and					
	various applica	various applications				
Soft skills	Ability to perf	orm individ	lual literat	ure search	, critical readi	ng,
	understanding	, and clear	didactic pr	esentation	n	
Contents	Advanced topi	cs in algori	thm design	based on	newest resear	ch
	literature					
Prerequisites	none					
Format	Teaching forms	at C	roup size	h/week	Workload[h]	CP
rormat	Seminar		10	2	30 T / 90 S	4
	T = face-to-fa	ce teaching	S = indep	endent st	udy	
Exam achievements	Oral presentat	ion, writter	report		(gra	ded)
Study achievements					(not gra	ded)
Forms of media						
Literature	The relevant l	iterature wi	ll be annoi	ınced in t	ime.	

Module	Lab Algorithms for Chip Design						
MA-INF 1308							
Workload	Credit points	Duration	Freque	-			
270 h	9 CP	1 semester	r every year				
Module	Prof. Dr. Jens	s Vygen					
coordinator							
Lecturer(s)		All lecturers of Discrete Mathematics					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 3.			
Technical skills	_	Competence to implement algorithms for VLSI design, efficient					
	handling of ve	ry large inst	ances, tes	sting, doc	umentation.		
	Advanced soft	ware techniq	ues.				
Soft skills	Efficient imple	Efficient implementation of complex algorithms, abstract					
	thinking, mode	elling of opti	mization	problem	in VLSI design.	,	
	documentation	of source c	ode				
Contents	A currently ch	allenging pr	oblem wi	ll be chos	en each semeste	er.	
	The precise ta	sk will be ex	plained i	n a meeti	ng in the previo	ous	
	semester.		-				
Prerequisites	Recommended	:					
	At least 3 of the	he following:					
	MA-INF 1102	- Combinat	orial Opt	imization			
	MA-INF 1202	– Chip Desi	gn				
	MA-INF 1205	- Graduate	Seminar	Discrete	Optimization		
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study	'	
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media					· -		
T	The topics and	the relevan	t literatu	re will be	announced tow	vards	
Literature	the end of the	previous ser	nester				

Module	Lab Efficien	t Algorit	nms: De	esign, A	nalysis and	
MA-INF 1309	Implementa	tion				
Workload	Credit points	Duration	Freque	ency		
270 h	9 CP	9 CP 1 semester at least every year				
Module	Prof. Dr. Heil	ko Röglin	·			
coordinator						
Lecturer(s)	Prof. Dr. Ann	e Driemel,	Prof. Dr.	Thomas 1	Kesselheim,	
	Prof. Dr. Heil	ko Röglin, F	D Dr. El	mar Lang	etepe,	
	Dr. Herman H	[averkort				
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	ter Science	Options	al 3.		
Technical skills	Ability to desi	gn, analyze	and impl	ement effi	cient algorithm	s for
	selected comp	ıtational pr	oblems.			
Soft skills	ability to work	on advanc	ed algorit	hmic imp	lementation	
	projects, to we	ork in small	teams, cl	ear didact	tic presentation	and
	critical discuss	ion of resul	ts			
Contents	Design of efficient	ient exact a	nd approx	imate alg	gorithms and da	ıta
	structures for	selected cor	nputation	al probler	ns.	
Prerequisites	none					
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP
Format	Lab		8	4	60 T / 210 S	9
	T = face-to-fa	ce teaching	S = inde	pendent s	study	
Exam achievements	Oral presentat	ion, writter	report		(gra	ided)
Study achievements					(not gra	$\overline{\mathrm{ded}}$
Forms of media						
Literature	The relevant li	terature wi	ll be anno	unced in	time.	

Module	Online Motion Planning					
MA-INF 1314						
Workload	Credit points	Duration	Freque	ency		
270 h	9 CP	1 semester	every	year		
Module	PD Dr. Elmar	Langetepe				
coordinator						
Lecturer(s)	Prof. Dr. Rolf	Klein, PD D	r. Elma	r Langete	epe	
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	iter Science	Optiona	al 1-4.		
Technical skills	To acquire fun	damental kn	owledge	on topics	and methods in	1
	online motion	planning				
Soft skills						
Contents	Search and ex	ploration in u	ınknown	environn	nents (e.g., grap	hs,
	cellular enviro	nmwents, pol	ygons, s	trets), onl	line algorithms,	
	competitive ar	nalysis, comp	etitive co	omplexity	functional,	
	optimization,	shortest watc	hman ro	ute, tethe	ered robots, man	rker
	algorithms, sp	iral search, a	pproxima	ation of o	ptimal search pa	aths.
Prerequisites	Recommended	:				
	BA-INF 114 –	Grundlagen	der algo	rithmisch	en Geometrie	
	Teaching forms	at Gro	up size	h/week	Workload[h]	CP
Format	Lecture			4	60 T / 105 S	5.5
	Exercises			2	30 T / 75 S	3.5
	T = face-to-fa	ce teaching; S	S = inde	pendent s	study	
Exam achievements	Oral exam				(gra	ded)
Study achievements	Successful exe	rcise participa	ation		(not gra	ded
Forms of media	Java applets o	f geometry la	b			
Literature	Scientific resea	arch articles v	vill be re	ecommend	led in the lectur	re.

Module MA-INF 1315	Lab Computational Geometry					
Workload	Credit points	Duration	Freque	ncy		
270 h	9 CP 1 semester every year					
Module	Prof. Dr. Ann	e Driemel	-			
coordinator						
Lecturer(s)		Prof. Dr. Anne Driemel, PD Dr. Elmar Langetepe, Dr. Herman Hayerkort				
GI IO II	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	iter Science	Optiona	1 2.		
Technical skills	Ability to design, analyze, implement and document efficient					
	algorithms for selected problems in computational geometry.					
Soft skills	Ability to properly present, defend and discuss design and					
	implementatio	n decisions,	to docum	ent softw	are according to	O
	given rules and	d to collabor	ate with o	other stu	dents in small	
	groups.					
Contents	Various proble	ems in comp	itational g	geometry	.	
Prerequisites	none					
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP
Format	Lab		8	4	60 T / 210 S	9
	T = face-to-fa	ce teaching;	S = indep	pendent s	study	
Exam achievements	Oral presentat	tion, written	report		(gra	ded)
Study achievements					(not gra	ded)
Forms of media		, , ,				
Literature	The relevant l	iterature wil	be annou	ınced in	time.	

Module	Lab Cryptography						
MA-INF 1316							
Workload	Credit points	Duration	Freque	ncy			
270 h	9 CP	1 semester	every y	vear			
Module	Dr. Michael N	l'üsken					
coordinator							
Lecturer(s)	Dr. Michael N	l'üsken					
Classification	Programme		Mode	Semes	ster		
Classification	M. Sc. Compu	iter Science	Optiona	1 2. or	3.		
Technical skills	The students	will carry ou	t a practi	cal task (project) in the		
	context of Cry	ptography, i	ncluding t	test and	documentation	of	
	the implement	ed software	system.				
Soft skills	Ability to prop	Ability to properly present and defend					
	design decision	ns, to prepar	e readable	e docume	entation of softw	vare;	
	skills in constr	ructively coll	aborating	with oth	ners in small tea	ms	
	over a longer p	period of tim	e; ability	to classif	y ones own resu	ılts	
	into the state-	of-the-art of	the resp.	area			
Contents							
Prerequisites	none						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Format	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inder	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature							

Module MA-INF 1320	Lab Advance	ced Algori	thms				
Workload	Credit points	Duration	Freque	ncy			
270 h	9 CP 1 semester at least every 2 years						
Module	Prof. Dr. Tho	Prof. Dr. Thomas Kesselheim					
coordinator							
Lecturer(s)	Prof. Dr. Tho	mas Kesselh	eim, Prof.	Dr. Hei	ko Röglin		
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	l 2. or	3.		
Technical skills	Implementation	Implementation of algorithms from advanced algorithmic theory,					
	evaluating the	evaluating these algorithm on suitably chosen instances, and					
	discussing how	theoretical	results tra	ansfer to	practice.		
Soft skills	Ability to prop	Ability to properly present, defend and discuss design and					
	implementatio	n decisions a	and observ	red concl	usions, and to		
	collaborate wi	th other stud	dents in sr	nall grou	ips.		
Contents	Various proble	ems from cur	rent resea	rch and	courses on		
	algorithmic th	eory.					
Prerequisites	none						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = indep	endent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ided)	
Study achievements					(not gra	ided)	
Forms of media							
Literature	The relevant l	iterature wil	l be annou	inced in	time.		

Module MA-INF 1321	Binary Line	ear and Q	uadratic	Optimi	zation		
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semeste	er at least every 2 years				
Module	Dr. Sven Mall	ach			-		
coordinator							
Lecturer(s)	Dr. Sven Mallach						
C1 10 11	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 2. or 3.					
Technical skills	Deeper unders	standing of	computation	nal meth	ods to solve		
	potentially lar	ge-scale mi	ked-integer	programs	s in practice.		
	Application-sp	Application-specific modelling and reformulation of					
	combinatorial optimization problems, handling quadratic objective functions, algorithm design.						
Soft skills	Social, methodological, and analytical competences via communication, own development, presentation, and critical						
	assessment of	problem for	mulations,	algorithm	ns, and solution	ns	
	covered in the	course or t	he excercise	es. Learni	ing to abstract	, but	
	also learning t	he limitation	ns of abstr	action.			
Contents	Computationa	l methods i	n (mixed-)	integer pr	ogramming suc	ch as	
	cutting plane	separation a	and branch	-and-bou	nd along with a	a	
	short and acce	essible intro	duction int	o their th	eoretical basis		
		-	_		d binary quadr		
	optimization p	oroblems, e.	g., Maximu	ım Cut, I	inear Ordering	ŗ	
	and variants o	f the Trave	ing Salesm	an proble	em, along with	the	
	particular sepa	aration prol	olems arisir	ng there.	If there is time	·,	
	linearizations	of quadration	objective	functions	and more		
	_	formulation	s of binary	quadratio	c problems are		
	discussed.						
Prerequisites	none						
	Teaching forms	at (Froup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	S = indep	endent st	udy		
Exam achievements	Oral exam		1			ded)	
Study achievements	Successful exe	rcise partici	pation		(not gra		
Forms of media		<u> </u>			·		
Literature							

Module	Seminar Focus Topics in High Performance					
MA-INF 1322	Computing					
Workload	Credit points	Duration	Freque	ncy		
120 h	4 CP	4 CP 1 semester every year				
Module	Prof. Dr. Estela Suarez					
coordinator						
Lecturer(s)	Prof. Dr. Este	la Suarez				
Classification	Programme		Mode	Semest	ter	
Classification	M. Sc. Compu	ter Science	Optiona	$1 \mid 2$. or 3	3.	
Technical skills	Ability to perf	orm individ	ual literati	ure search	, critical readi	ng,
	understanding	, prepare a	concise sur	nmary, ar	nd clear didact	ic
	presentation					
Soft skills	Ability to pres	Ability to present and critically discuss these results in the				
	framework of t	he correspo	nding area	L		
Contents	General topics	and trends	in high pe	rformance	e computing, b	ased
	on recent revie	ew and resea	rch literat	ure		
Prerequisites	Recommended	1				
	Interest in Hig	h Performa	nce Compu	ıting		
Format	Teaching forma	nt G	roup size	h/week	Workload[h]	CP
rormat	Seminar		10	2	30 T / 90 S	4
	T = face-to-face	ce teaching;	S = indep	endent st	udy	
Exam achievements	Oral presentat	ion, written	report		(gra	ded)
Study achievements					(not gra	ded)
Forms of media						
Literature	Literature and announced in t				seminar will b	e

36.1.1	C						
Module MA-INF 1323	Computation	onai 10poi	ogy				
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	at leas	t every 2	years		
Module	Prof. Dr. Ann	e Driemel			-		
coordinator							
Lecturer(s)	Prof. Dr. Ann	Prof. Dr. Anne Driemel, Dr. Benedikt Kolbe					
CI 'C '	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.		
Technical skills	Knowledge of	fundamenta	theorem	s and con	cepts in the are	ea of	
	computational	computational topology in particular, persistent homology and					
	topological da	ta analysis;	design an	d analysis	s of combinator	ial	
	algorithms in	topological o	ontexts;	analysis o	of the complexit	y; to	
	apply this kno	wledge auto	nomously	to solvin	g new problems	s and	
	analysing new	data sets.					
Soft skills	Social compete	•		_	_		
		olutions, goal-oriented discussions in teams), methodical					
	competence (a						
	`	ommitment	and willing	ngness to	learn, creativity	y,	
	perseverance).						
Contents		-			and cohomology	7	
	theory and per		-	_	= :		
		-			or the computat		
	\ <u>-</u>	J		-	nce modules an		
	_				theorems, quive	r	
	_				e diagrams and		
	barcodes, alge			_			
					sistence, topolo	gicai	
	data analysis, machine learni		_	_			
D	none	ing, identific	ation of g	eometric	objects.		
Prerequisites	Teaching forms	ot Cn	oup size	h/week	Workload[h]	СР	
Earmant	Lecture	at Gr	oup size	4	60 T / 105 S	5.5	
Format	Exercises			2	30 T / 75 S	3.5	
			() ()		,	0.0	
	T = face-to-fa		S = inde	pendent s		1 1\	
Exam achievements	Schriftliche Pr					ided)	
Study achievements	Erfolgreiche Ü	bungsteilnal	ime		(not gra	ided)	
Forms of media	TT 1 . TD 1	11 7	1 77	(2010)	<u> </u>		
				` ,	Computational		
	Topology: An Introduction. American Mathematical Society.						
	• Steve Oudot (2015). Persistence Theory: From Quiver Representations to Data Analysis (Vol. 209). American						
			naiysis (voi. 209).	. American		
Literature	Mathematical	·	Miolo - 1 T	ogni:-1- (0	099) 4		
	Magnus Bak Introduction t			,	022). An		
	Introduction t	_			(V_01, AA)		
	Allen Hatche Cambridge Ur	, ,	_	горогоду	(voi. 44).		
	Cambridge University Press.						

2 Graphics, Vision, Audio

MA-INF 2113	L2E2	6 CP	Foundations of Audio Signal Processing	37
MA-INF 2201	L4E2	9 CP	Computer Vision	38
MA-INF 2203	L4E2	9 CP	Selected Topics in Signal Processing	39
MA-INF 2206	Sem2	4 CP	Seminar Vision	40
MA-INF 2207	Sem2	4 CP	Seminar Graphics	41
MA-INF 2208	Sem2	4 CP	Seminar Audio	42
MA-INF 2209	L4E2	9 CP	Advanced Topics in Computer Graphics I	43
MA-INF 2212	L2E2	6 CP	Pattern Matching and Machine Learning for Audio Signal	1
			Processing	44
MA-INF 2213	L3E1	6 CP	Computer Vision II	45
MA-INF 2214	L2E2	6 CP	Computational Photography	46
MA-INF 2215	Sem2	4 CP	Seminar Digital Material Appearance	47
MA-INF 2216	Lab4	9 CP	Lab Visual Computing	48
MA-INF 2217	L2E2	6 CP	Advanced Deep Learning for Graphics	49
MA-INF 2218	L2E2	6 CP	Video Analytics	50
MA-INF 2219	Sem2	4 CP	Seminar Visualization and Medical Image Analysis	51
MA-INF 2220	Lab4	9 CP	Lab Visualization and Medical Image Analysis	52
MA-INF 2221	Sem2	4 CP	Seminar Visual Computing	53
MA-INF 2222	L4E2	9 CP	Visual Data Analysis	54
MA-INF 2307	Lab4	9 CP	Lab Vision	55
MA-INF 2308	Lab4	9 CP	Lab Graphics	56
MA-INF 2309	Lab4	9 CP	Lab Audio	57
MA-INF 2310	L4E2	9 CP	Advanced Topics in Computer Graphics II	58
MA-INF 2312	L3E1	6 CP	Image Acquisition and Analysis in Neuroscience	59
MA-INF 2313	L2E2	6 CP	Deep Learning for Visual Recognition	60
MA-INF 2314	L4E2	9 CP	Image Processing, Search and Analysis I	61
MA-INF 2315	L4E2	9 CP	Seminar Computational Photography	62
MA-INF 2316	L4E2	9 CP	Lab Digital Material Appearance	63
			Numerical Algorithms for Visual Computing and Machine	
			Learning	64

Module	Foundations of Audio Signal Processing						
MA-INF 2113							
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semeste	er every y	every year			
Module	apl. Prof. Dr.	Frank Kur	th				
coordinator							
Lecturer(s)	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen						
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	ter Science	Optiona	l 1.			
Technical skills	• Introduction	• Introduction to basic concepts of analog and digital signal					
	processing;	6,					
		• Applications in the field of Audio Signal Processing;					
	• Signal Proce	• Signal Processing Algorithms;					
	_	• Implementing basic Signal Processing Algorithms					
Soft skills		Solving basic Signal Processing Problems; Implementing Signal					
	Processing Alg	•	0				
	frameworks; C						
		,	_	olutions a	and solutions o	f	
	others, and wo						
Contents			0	0	l Signal Proces	sing;	
	Fourier Transf	,			, .		
	Filters; Audio	_					
	Windowed For	ırier Transf	orm; 2D-Si	gnal Proc	essing		
Prerequisites	none				I		
	Teaching forms	at C	Froup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	S = indep	endent st	udy		
Exam achievements	Written exam				(gra	ded)	
Study achievements	Successful exer	rcise partici	pation		(not gra	$\overline{\operatorname{ded}}$	
Forms of media	Slides, Blackboard, Whiteboard						
Literature							

Module	Computer V	Vision					
MA-INF 2201							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	r every year				
Module	Prof. Dr. Jürg	gen Gall					
coordinator							
Lecturer(s)	Prof. Dr. Jürgen Gall						
Classification	Programme		\mathbf{Mode}	Semes			
Classification	M. Sc. Compu		Optiona				
Technical skills	Students will l	earn about v	arious m	athemati	cal methods and	d	
	their applicati	their applications to computer vision problems.					
Soft skills	Productive wo	Productive work in small teams, development and realization of					
	individual app	individual approaches and solutions, critical reflection of					
		competing methods, discussion in groups.					
Contents		The class will cover a number of mathematical methods and					
		_			ample, linear fil		
					tation, graph cu	ıts,	
	mean shift, ac		*	,	_		
	· · · · · · · · · · · · · · · · · · ·	_			oral filtering, a		
		, -	_	,	cracking, camera	· ·	
	· '			,	pose estimation	′	
	_		, deform	able mesh	nes, RGBD visio	on.	
Prerequisites	Recommended						
		_	lgebra, a	nalysis, p	probability theor	ry,	
	C++ program						
	Teaching forms	at Gro	up size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Written exam				(gra	ded)	
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)	
Forms of media							
	• R. Hartley,	A. Zisserman	: Multip	le View G	eometry in		
T it anatuma	Computer Vis	ion					
Literature	• R. Szeliski:	Computer Vi	sion: Alg	gorithms a	and Application	ns	
	• S. Prince: C	omputer Visi	on: Mod	lels, Learı	ning, and Infere	nce	

Module	Selected To	pics in Sign	nal Pro	cessing			
MA-INF 2203							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	every	year			
Module	apl. Prof. Dr.	Frank Kurth					
coordinator							
Lecturer(s)	apl. Prof. Dr.	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu		Optiona				
Technical skills	Learning adva	Learning advanced as well as state of the art topics and					
	•		-		examples from		
	0		-	_	focus on music		
		audio. Develop skills for analysing audio signals and designing					
		audio features for selected application scenarios. Mathematical					
	_	modelling of signal processing problems in practical applications.					
	0	Design and implementation of corresponding algorithms and					
		data structures solving those problems. Efficiency issues.					
Soft skills	Capability to analyze. Time management. Strength of purpose. Discussing own solutions and solutions of others.						
						C	
Contents	Advanced techniques for filter design, design and extraction of features describing multimedia signals, efficient DSP algorithms,						
		_	_		_	nms,	
	general concep			-			
	_		_		ns, for example		
	source separat		s, signa	compres	sion, denoising,		
Prerequisites	none	1011.					
Frerequisites	Teaching forms	ot Cros	up size	h/week	Workload[h]	CP	
Format	Lecture	at Gro	up size	4	60 T / 105 S	5.5	
Format	Exercises			2	30 T / 75 S	3.5	
					,	5.5	
	T = face-to-fa	ce teaching; S	s = inde	pendent s		1 1\	
Exam achievements	Written exam	. ,	1.		· -	aded)	
Study achievements	Successful exe	rcise participa	tion		(not gra	aded)	
Forms of media	т , .	4 1 1 4	1	1 11.	· ·		
	• Lecture scrip			-			
	• Hayes: Statistical Digital Signal Processing and Modelling,						
T:44	John Wiley, 1996 • Prophic Manalakia, Digital Signal Processing, Prophica Hall						
Literature	• Proakis, Manolakis: Digital Signal Processing, Prentice Hall, 1996						
		vv. Signal Pro	ncessing	Methods	s for Music		
	• Klapuri, Davy: Signal Processing, Methods for Music Transcription, Springer, 2006						
	Transcription,	Springer, 200	,,,				

Module MA-INF 2206	Seminar Vision						
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	1 semester					
Module	Prof. Dr. Jürg	Prof. Dr. Jürgen Gall					
coordinator							
Lecturer(s)	Prof. Dr. Jürg	gen Gall					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.		
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	scientific papers.					
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the					
	framework of	the correspon	nding area	•			
Contents	Current confer	rence and jou	ırnal pape	rs.			
Prerequisites	Required:						
	MA-INF 2201	- Computer	Vision				
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentat	tion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 2207	Seminar Graphics						
Workload	Credit points	Duration	1	Freque	ncy		
120 h	4 CP	1 semes	ter	every s	emester		
Module	Prof. Dr. Reinhard Klein						
coordinator							
Lecturer(s)	Prof. Dr. Rein	Prof. Dr. Reinhard Klein					
Classification	Programme			Mode	Semest	ter	
Classification	M. Sc. Computer Science			Optiona	$1 \mid 2$. or 3	3.	
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	scientific papers.					
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the					
		framework of the corresponding area.					
Contents	Current confer	rence and	jour	nal pape	ers.		
Prerequisites	Recommended	:					
	Mathematical	backgroun	ad (:	multidim	nensional	analysis and li	near
	algebra, basic	numerical	me	thods)			
	Basic knowled	ge in Com	put	er Grapl	nics		
To 4	Teaching forms	at	Gro	oup size	h/week	Workload[h]	CP
Format	Seminar			10	2	30 T / 90 S	4
	T = face-to-fa	ce teachin	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en r	eport		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature							

Module MA-INF 2208	Seminar Au	dio					
Workload	Credit points	Duration	Frequen	cy			
120 h	4 CP 1 semester every semester						
Module	apl. Prof. Dr.	apl. Prof. Dr. Frank Kurth					
coordinator							
Lecturer(s)	apl. Prof. Dr.	apl. Prof. Dr. Frank Kurth, Dr. Michael Clausen					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Comput	ter Science	Optional	2.	2.		
Technical skills	Ability to unde	Ability to understand new research results presented in original					
	scientific paper	scientific papers.					
Soft skills	Ability to prese	ent and to c	ritically di	scuss the	se results in th	ıe	
	framework of the	he correspor	iding area.				
Contents	Current confere	ence and jou	rnal paper	s.			
Prerequisites	none						
Format	Teaching forma	t Gı	oup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-face	ce teaching;	S = independent	endent st	udy		
Exam achievements	Oral presentati	on, written	report		(gra	ded)	
Study achievements					(not gra	\overline{ded}	
Forms of media							
Literature							

26.11	A d d T		<u></u>	-4 0		T	
Module MA-INF 2209	Advanced T	opics in	Comp	iter G	rapn	iics i	
Workload	Credit points	Duration	Frequ	onav			
270 h	9 CP	1 semester	every	-			
Module	Prof. Dr. Reinha		cvery	ycai			
coordinator	Troi. Dr. Itemna	ra mem					
Lecturer(s)	Prof. Dr. Reinha	rd Klein					
	Programme		Iode	Semes	ter		
Classification	M. Sc. Computer	Science	ptional	2. or 3.			
Technical skills	Analytical formul principles, technic	_			enderin	g. Knowledge of	
	• recognize and understand the physical quantities of light transport						
	• explain a range						
	• explain the rend						
	• design and imp	_			_		onte
	Carlo methods				-	, 1	
	• Assess / Evalua implemented simu		rmance ar	nd conce	ptual li	imits of the	
Soft skills	Based on the kno		kills acqu	ired stu	dents s	hould be able to	
	• read and judge	current scie	tific liter	ature in	the are	ea of rendering	
	• identify the ma					_	and
	gain an overview of the current state of the art						
	• discuss problems concerning rendering with researchers from different						
	application fields			~			
	• present, propose and communicate different solutions and work in a team						
	to solve a rendering problem						
Contents	This course introduces the basic physical quantities as well as the						
	mathematical and algorithmic tools required to understand and simulate the						
	light interaction with objects and different materials in a 3D scene. We will discuss how to solve the mathematical problem numerically in order to						
	create realistic im			_		-	
	material models f	_	_		_		nte
	Carlo Methods.						
	• rendering and r	adiative trai	sfer equa	tion			
	• methods and al		_		ons, ra	diosity, Monte Ca	ırlo,
	photon mapping			•	,	0 /	,
	• analytical and o	data driven s	urface an	d subsur	face m	aterial models,	
	especially BRDF,		odels				
	• differentiable re	endering					
	In addition, result	ts from state	-of-the-ar	t researc	h will	be presented.	
Prerequisites	Recommended:						
	Recommended by				ge in c	omputer graphics	,
	(numerical) analy					*** 11 101	GD
TD 4	Teaching forma	ıt (Group si	ze h/	week	Workload[h]	CP
Format	Lecture Exercises				$\frac{4}{2}$	60 T / 105 S	5.5
						30 T / 75 S	3.5
To 1.	T = face-to-face			dent stu	dy		1 2
Exam achievements	Oral presentation					,-	aded)
Study achievements	Successful exercis	e participati	on			(not gra	aded)
Forms of media	• M. Pharr, W. J	akob and C	Humph.	ove Dh-	reicoll	Rasad Randanina	r•
	From Theory to I					Dased Rendering	5 •
						llumination Insti	itute
T	• L. Szirmay-Kalos: Monte-Carlo Methods in Global Illumination, Institute of Computer Graphics, Vienna University of Technology, Vienna, 1999 URL:						
Literature	https://cg.iit.bme					50,, 1000	
	• P. Dutre, K. Ba				bal Illu	mination, 2nd ed	٠.,
	B&T, 2006	•				•	
	• D'Eon, Eugene.	A Hitchhik	er's Guide	e to Mul	tiple S	cattering, 2016	

Module	Pattern Matching and Machine Learning for Audio						
MA-INF 2212	Signal Processi	ng					
Workload	Credit points Dur	ration	Frequer	ncy			
180 h	6 CP 1 s	semester	every y	ear			
Module	apl. Prof. Dr. Fran	ık Kurth					
coordinator							
Lecturer(s)	apl. Prof. Dr. Fran	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Computer Science Optional 2.						
Technical skills	• Introduction into	• Introduction into selected topics of digital signal processing;					
	• Applications in t	he field c	of Audio S	Signal Pro	ocessing;		
	• Methods of Auto	Methods of Automatic Pattern Recognition					
Soft skills	Audio Signal Proce	Audio Signal Processing Applications; Extended programming					
	skills for signal pro	skills for signal processing applications; Capability to analyze;					
	Time management	; Present	ation skil	ls; Discus	ssing own solut	ions	
	and solutions of ot		_				
Contents	The lecture is present						
	motivated from the			_	-	re:	
	Windowed Fourier		,		,		
	Matching; Signal C		tion; Hidd	len Marko	ov Models;		
	Support Vector Ma	chines					
Prerequisites	none						
	Teaching format	Gre	oup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-face te	aching; S	S = indep	endent st	udy		
Exam achievements	Written exam				(gra	ded)	
Study achievements	Successful exercise	participa	ation		(not gra	ded)	
Forms of media	Slides, Blackboard, Whiteboard						
Literature							

Module MA-INF 2213	Computer	Vision II					
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semeste	er every y	vear			
Module	Prof. Dr. Jürg	gen Gall	'				
coordinator							
Lecturer(s)	Prof. Dr. Jürgen Gall						
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona	$1 \mid 2$. or 3	3.		
Technical skills	Students will l	earn about	various lea	arning me	thods and their	r	
	applications to	applications to computer vision problems.					
Soft skills	Productive wo	Productive work in small teams, development and realization of					
	individual app	individual approaches and solutions, critical reflection of					
	competing methods, discussion in groups.						
Contents	The class will cover a number of learning methods and their						
	applications in	computer	vision. For	example,	linear method	s for	
	classification a	nd regressi	on, boostin	ıg, randon	n forests, neura	al	
	networks, SVN	Is, prototy	oe methods	s, nearest	neighbors,		
	_	,	<u> </u>		ed learning, ima	age	
	classification,	· ·	,	n recogni	tion, pose		
	estimation, fac	e analysis,	tracking.				
Prerequisites	Required:						
	MA-INF 2201			1			
	Teaching forms	at (Group size	h/week	Workload[h]	CP	
Format	Lecture			3	45 T / 45 S	3	
	Exercises			1	15 T / 75 S	3	
	T = face-to-fa	ce teaching	S = indep	pendent st	tudy		
Exam achievements	Oral exam				(gra	ded)	
Study achievements	Successful exe	rcise partic	pation		(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 2214	Computational Photography						
Workload	Credit points	Duration	Frequer	ncy			
180 h	6 CP	1 semester	r every year				
Module	Prof. Dr. Mat	thias Hullin					
coordinator							
Lecturer(s)	Prof. Dr. Mat	thias Hullin					
	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	l 2. or 3	3.		
Technical skills	Foundations in optics and image sensors. Signal processing and						
	inverse problems in imaging. Color spaces and perception.						
	Image alignme	ent and blend	ling. High	- -dimensio	onal		
					reflectance fiel	lds,	
	reflectance dis	tributions).	Computat	ional illui	mination.		
Soft skills	• to read and	understand o	urrent lite	erature in	the field		
	• to implemen	t standard co	omputatio	nal photo	ography technic	ques	
	• to propose and implement solutions to a given problem						
	• to follow goo	od scientific p	oractice by	y planning	g, documenting	r S	
	and communic	cating their v	ork				
Contents	• Image sensor	rs					
	• Optics						
	• Panoramas						
	• Light fields						
	• Signal proce	ssing and inv	erse prob	lems			
	• Color, perce	ption and HI	OR				
	• Reflectance	fields and lig	ht transpo	ort matric	ees		
Prerequisites	Required:						
	Basic knowled	ge in comput	er graphi	cs, data s	tructures,		
	multidimension	nal analysis	ınd linear	algebra,	numerical anal	lysis	
	and numerical	linear algebra	ca, C++ c	or MATL	AB		
	Teaching forms	at G1	oup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching:	S = index	endent st	udy	-	
Exam achievements	Oral exam	-01				ded)	
Study achievements	Successful exer	rcise particip	ation		(not gra		
Forms of media		1 · · · · · · · · · · · · · · · · · · ·			(0	/	
forms of media							

Module MA-INF 2215	Seminar Digital Material Appearance						
Workload	Credit points	Duration	Frequen	ıcy			
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Mat	Prof. Dr. Matthias Hullin					
coordinator							
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthias Hullin					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	ter Science	Optional	2.			
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific paper	scientific papers.					
Soft skills	Ability to pres	ent and to c	ritically di	scuss the	se results in th	ne	
	framework of t	he correspon	nding area	•			
Contents	Current confer	ence and jou	ırnal pape	rs			
Prerequisites	none						
Format	Teaching forma	at G	oup size	h/week	Workload[h]	CP	
rormat	Seminar		10	2	30 T / 90 S	4	
	T = face-to-face	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature							

Module MA-INF 2216	Lab Visual Computing						
Workload	Credit points	Duration	Freque	nev			
270 h	9 CP	1 semester	every	•			
Module	JunProf. Dr. Florian Bernard						
coordinator	oun. 1101. B1.	riorian Ber	iiai a				
Lecturer(s)	JunProf. Dr. Florian Bernard						
	Programme		Mode	Seme	ster		
Classification	M. Sc. Computer Science		Optiona	al 1-3.			
Technical skills			ractical t	ask (proj	ect) in the cont	ext	
				(1 0	mentation of th		
	implemented software/system.						
Soft skills	*	Ability to properly present and defend design decisions, to					
		prepare readable documentation of software; skills in					
	constructively	collaboratin	g with ot	hers in sr	nall teams over	a	
	longer period o	of time; abili	ty to clas	sify ones	own results into	o the	
	state-of-the-ar						
Contents	This lab introd	duces visual	computin	ng method	ds and applicati	ons.	
	You will get a	chance to st	udy the i	methods i	in depth by		
	implementing	them and ru	nning exp	periments	s. At the end of	the	
	semester, you	will present	the meth	od, give a	a short		
	demonstration	and hand in	a report	t describii	ng the method a	and	
	experimental of	outcomes.					
Prerequisites	none						
Format	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module	Advanced I	Deep Lear	ning for	Graphic	es		
MA-INF 2217							
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semeste	r every y	ear			
Module	Prof. Dr. Rein	hard Klein					
coordinator							
Lecturer(s)	Dr. Michael W	Veinmann					
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optional	l 1-4.			
Technical skills	Students will b	oe introduce	ed to adapt	and app	ly deep learnir	ıg	
	techniques to	various appl	ications in	compute	r graphics.		
Soft skills	Productive wo	rk in small	teams, dev	elopment	and realizatio	n of	
	individual app	roaches and	solutions,	critical r	effection of		
	competing me	thods, discu	ssion in gr	oups.			
Contents	This course for	cuses on cu	ting-edge	Deep Lea	rning techniqu	es	
	for computer g	r computer graphics. After a brief review of CNNs the focus					
	will be laid on	will be laid on autoencoders, generative models and the					
	extension of the	nese method	s to $graph$	and mar	nifold-structur	$_{ m ed}$	
	data. Applicat	tions discuss	sed will inc	lude inve	rse problems ii	1	
	computer grap	phics and th	e synthesis	of model	ls including da	ta	
	completion and	d super-reso	lution.				
Prerequisites	Recommended						
	The course wil	-			_	well	
	as fundamenta						
	Therefore, it is	0 0			-		
	Learning for V	_					
	prerequisite. E	Exercises wil	l be a mix	of theory	and practical		
	(Python).						
	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching;	S = indep	endent st	tudy		
Exam achievements	Written exam				(gra	ided)	
Study achievements	Successful exe	rcise partici	pation		(not gra	ided)	
Forms of media						*	
Literature	No required te	ext, supplem	ental read	ings will l	be given in cla	SS.	

Module MA-INF 2218	Video Anal	ytics					
Workload	Credit points	Duration	Frequer	ncv			
180 h	6 CP	1 semester	_	every 2	years		
Module	Prof. Dr. Jürg	gen Gall			•		
coordinator							
Lecturer(s)	Prof. Dr. Jürg	gen Gall					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	l 2-4.			
Technical skills	Students will l	tudents will learn advanced techniques for analyzing video data.					
Soft skills	Productive wo	Productive work in small teams, development and realization of					
	a state-of-the-	state-of-the-art system for video analysis.					
Contents	The class will	The class will discuss state-of-the-art methods for several tasks					
	of video analys	sis. For exan	ple, video	clip class	sification, temp	oral	
	video segment	ation, spatio	-temporal	action $d\epsilon$	etection, video		
	context, spatio	o-temporal n	odeling of	f humans	and objects,		
		fordance, vi	deo summ	arization	, semantic vide	90	
D	segmentation.						
Prerequisites	Required:	Commutan	Vision				
	MA-INF 2201			1- /1-	3371-11[1-1	CD	
TD 4	Teaching forms Lecture	at G	oup size	h/week	Workload[h]	2.5	
Format	Exercises			$\frac{2}{2}$	'	3.5	
					30 T / 75 S	5.5	
	T = face-to-fa	ce teaching;	S = indep	endent st			
Exam achievements	Oral exam				(0	ded)	
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 2219	Seminar Vi	sualizatio	n and Mo	edical In	mage Analys	sis	
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	Property of the second					
Module	Prof. Dr. Tho	mas Schult	Z				
coordinator							
Lecturer(s)	Prof. Dr. Tho	Prof. Dr. Thomas Schultz					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Computer Science		Optional	$\lfloor \ $			
Technical skills		Ability to understand new research results presented in original scientific papers.					
Soft skills	Ability to pres	Ability to present and to critically discuss scientific results in the					
	context of the	context of the current state of the art. Ability to perform an					
	independent se	ndependent search for relevant scientific literature.					
Contents	Current confer	rence and jo	urnal pape	ers			
Prerequisites	Recommended	:					
	At least one of	f the follow	ng:				
	• MA-INF 222	22 – Visual	Data Analy	vsis			
	• MA-INF 231	12 - Image	Acquisition	and Ana	lysis in		
	Neuroscience						
TD 4	Teaching forms	at (Froup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching	S = indep	endent st	udy		
Exam achievements	Oral presentat	tion, writter	report		(gra	ded)	
Study achievements					(not gra	ded	
Forms of media							
Literature							

Module	Lab Visuali	zation and	Medic	al Imag	e Analysis		
MA-INF 2220							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	every	every semester			
Module	Prof. Dr. Tho	mas Schultz					
coordinator							
Lecturer(s)	Prof. Dr. Tho	mas Schultz					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Option	al 2.			
Technical skills	The students	will carry ou	t a pract	ical task	(project) in the		
	context of data	a visualizati	on and vi	sual anal	ytics or medical		
	image analysis	, including t	est and d	locument	ation of the		
	implemented s	nplemented software/system.					
Soft skills	Ability to properly present and defend design decisions, to						
	prepare readal	ole documen	tation of	software;	skills in		
	constructively	collaboratin	g with ot	thers in sr	nall teams over	a	
	longer period	of time; abil	ty to clas	ssify ones	own results into	o the	
	state-of-the-ar	t of the resp	. area				
Contents							
Prerequisites	Recommended	:					
	At least one of	f the following	ng:				
	• MA-INF 222	22 – Visual I	Oata Ana	lysis			
	• MA-INF 231	2-Image A	cquisitio	n and An	alysis in		
	Neuroscience						
D .	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Format	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study	•	
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded	
Forms of media							
Literature							

Module MA-INF 2221	Seminar Vis	sual Comp	outing			
Workload	Credit points	Duration	Freque	ncy		
120 h	4 CP	1 semester	at least	every ye	ar	
Module	JunProf. Dr.	Florian Be	rnard			
coordinator						
Lecturer(s)	JunProf. Dr.	JunProf. Dr. Florian Bernard				
Classification	Programme		Mode	Semes	ter	
Classification	M. Sc. Compu	ter Science	Optional	$1 \mid 2$. or 3	3.	
Technical skills		Ability to understand new research results presented in original scientific papers.				inal
Soft skills	* *	Ability to present and to critically discuss these results in the				16
Soft Skills		framework of the corresponding area.				
Contents		Current conference and journal papers.				
Prerequisites	Required:	J	1 1			
•	_	uirements. I	Participant	s are exp	ected to have s	some
	previous expos		-	_		
	- visual compu	iting (e.g. co	omputer vi	sion, com	puter graphics	s, 3D
	shape analysis	0 (0	-	,		,
	- mathematica	l optimisati	on (e.g. co	mbinator	ial/continuous	
	convex/non-co	-	, ,		,	,
	- machine lear	ning.				
_	Teaching forms		roup size	h/week	Workload[h]	CP
Format	Seminar		10	2	30 T / 90 S	4
	T = face-to-fa	ce teaching;	S = indep	endent st	cudy	
Exam achievements	Oral presentat	ion, written	report		(gra	ded)
Study achievements					(not gra	ded)
Forms of media						
Literature						

Module MA-INF 2222	Visual Data	a Analysis						
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every	year				
Module	Prof. Dr. Tho	mas Schultz	1					
coordinator								
Lecturer(s)	Prof. Dr. Tho	mas Schultz						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optiona	al 1-4.				
Technical skills	Ability to desi	gn, implemen	t, and n	nake prop	er use of systen	ns		
	for visual data	analysis. Kr	owledge	of algori	thms and			
	techniques for	the visualiza	tion of n	nulti-dime	ensional data,			
	graphs, as wel	l as scalar, ve	ctor, an	d tensor f	ields.			
Soft skills	Productive wo	ork in small te	ams, sel	f-depende	ent solution of			
	practical prob	lems in the ar	ea of vis	sual data	analysis, critica	ıl		
	reflection on v	risualization d	esign, p	resentatio	n of solution			
	strategies and	implementati	ions, self	manager	nent			
Contents	This class pro	vides a broad	overviev	w of princ	ciples and			
	algorithms for	data analysis	ta analysis via interactive visualization.					
	Specific topics include perceptual principles, luminance and							
	color, visualization analysis and design, integration of visual							
	with statistica	ical data analysis and machine learning, as well as						
	specific algorit	thms and tech	niques f	or the dis	splay of			
				-	tion, graphs, dir	rect		
	and indirect v	olume visuali	zation, v	ector field	d and flow			
	visualization,	as well as ten	sor field	visualiza	tion.			
Prerequisites	Recommended							
					nowledge in line	ear		
	_				programming.			
	Teaching forms	at Gro	up size	h/week	Workload[h]	CP		
Format	Lecture			4	60 T / 105 S	5.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching; S	S = inde	pendent s	study			
Exam achievements	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise participa	ation		(not gra	ded)		
Forms of media		-						
	A.C. Telea, Da Press, Second			nciples ar	nd Practice. CR	C C		
Literature	M. Ward et al., Interactive Data Visualization: Foundations, Techniques, and Applications. CRC Press, 2010							
	T. Munzner, V 2015	Visualization .	Analysis	and Desi	gn, A K Peters	,		

Module MA-INF 2307	Lab Vision						
Workload	Credit points	Duration	Freque	ncv			
270 h	9 CP	1 semester	_	semester			
Module	Prof. Dr. Jürg	gen Gall	U				
coordinator		,					
Lecturer(s)	Prof. Dr. Jürg	Prof. Dr. Jürgen Gall					
GI 10 H	Programme		Mode	Semes	ster		
Classification	M. Sc. Compu	ter Science	Optiona	1 2. or	3.		
Technical skills	The students	will carry ou	a practi	cal task ((project) in the		
	context of RG	context of RGB-D cameras.					
Soft skills	Ability to prop	Ability to properly present and defend design decisions, to					
	prepare readal	ole document	ation of s	software;	skills in		
	constructively	collaboratin	g with otl	hers in sr	nall teams over	a	
	longer period	of time; abili	ty to class	sify ones	own results into	the the	
	state-of-the-ar	t of the resp	area				
Contents	RGBD camera	s: research t	opics and	l applicat	ions		
Prerequisites	Required:						
	MA-INF 2201	- Computer	Vision				
	Good C++ pr	ogramming	kills				
Format	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = indep	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
	A. Fossati, J.	Gall, H. Gra	oner, X. I	Ren, K. F	Konolige. Consu	mer	
Literature	Depth Camera	Depth Cameras for Computer Vision: Research Topics and					
	Applications						

Module MA-INF 2308	Lab Graphi	cs					
Workload	Credit points	Duration]	Frequen	cy		
270 h	9 CP	1 semest	er	every se	mester		
Module	Prof. Dr. Reir	hard Klei	n				
coordinator							
Lecturer(s)	Prof. Dr. Reir	nhard Klei	n				
CI 10 II	Programme		N	Iode	Semes	ster	
Classification	M. Sc. Compu	M. Sc. Computer Science		ptional	3.		
Technical skills	The students v	will carry o	out a	practica	al task ((project) in the	
	context of geor	metry prod	cessin	ıg, rende	ering, sc	ientific visualiza	ation
	or human com	r human computer interaction, including test and					
	documentation	documentation of the implemented software/system.					
Soft skills	Ability to prop	Ability to properly present and defend design decisions, to					
	prepare readal	ole docume	entati	ion of so	oftware;	skills in	
	constructively	collaborat	ing w	vith other	ers in sr	nall teams over	a
	longer period	of time; ab	ility 1	to classi	fy ones	own results into	the the
	state-of-the-ar	t of the re	sp. aı	rea			
Contents	Varying selected	ed topics of	elose t	to curre	nt resea	rch in the area	of
	0 0 2	0,	derin	ng, scien	tific visi	ualization or hu	man
	computer inter	raction.					
Prerequisites	none						
Format	Teaching forms	at (Froup	size l	n/week	Workload[h]	CP
Tormat	Lab		8		4	60 T / 210 S	9
	T = face-to-fa	ce teaching	g; S =	= indepe	endent s	study	
Exam achievements	Oral presentat	ion, writte	en rep	port		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature							

Module	Lab Audio						
MA-INF 2309							
Workload	Credit points	Duration	Frequ	ency			
270 h	9 CP	1 semest	er every	year			
Module	apl. Prof. Dr.	Frank Ku	rth				
coordinator							
Lecturer(s)	apl. Prof. Dr.	Frank Ku	rth, Prof.	Dr. Micha	ael Clausen		
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Scienc	e Option	al 3.			
Technical skills	The students v	will carry o	out a pract	ical task	(project) in the		
	context of aud	context of audio and music processing, including test and					
	documentation of the implemented software/system.						
Soft skills	Ability to prop	perly prese	nt and def	end design	n decisions, to		
	prepare readal	ole docume	entation of	software;	skills in		
	constructively	collaborat	ing with o	thers in si	mall teams over	a	
	longer period	of time; ab	ility to cla	ssify ones	own results into	o the	
	state-of-the-ar	t of the res	sp. area.				
Contents							
Prerequisites	none						
Format	Teaching forms	at C	roup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching	g; S = inde	ependent s	study		
Exam achievements	Oral presentat	ion, writte	n report		(gra	ided)	
Study achievements			<u> </u>		(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature							

Module MA-INF 2310	Advanced T	opics in	Comput	er Graph	nics II	
Workload	Credit points	Duration	Freque	ncy		
270 h	9 CP	1 semeste	r every y	ear		
Module	Prof. Dr. Reinh	ard Klein				
coordinator						
Lecturer(s)	Prof. Dr. Reinh	ard Klein				
Classification	Programme		Mode	Semester		
	M. Sc. Compute		Optional	3.		
Technical skills	Analytical form	ulation of p	roblems rel	ated to geor	metry processing	g:
	apply methodapply basic coreal world appliDesign and in	oncepts of st cations aplement no	atistical shovel applica	ape analysis tion softwar	e in this area	
Soft skills	Based on the kr	nowledge an	d skills acq	uired studer	nts should be ab	ole to
	geometry proces • present, proporteam to solve ge	gain an over aajor literatiessing ose and come cometry pro- try processi	rview of the ure relevant municate decessing pro-	e current sta t for solving lifferent solu blems		n in in a
Contents	This course will first introduce the mathematical and algorithmic tools required to represent, model, and process 3D geometric objects. The second part discusses the latest mathematical, algorithmic, and statistical tools required for the analysis and modeling of 3D shape variability, which can facilitate the creation of 3D models. Topics among others will be • classical and discrete differential geometry of curves and surfaces					
	 mesh data structures and generation of meshes from point clouds Laplacian operator and optimization techniques with application denoising, smoothing, decimation, shape fitting, shape descriptors, geodesic distances parameterization and editing of surfaces point cloud registration correspondences shape spaces and statistical shape analysis 					
Prerequisites	In addition, result none		01 0110 0		······ se presente	
_ 101044101000	Teaching forma	at	Group size	h/week	Workload[h]	CP
Format	Lecture			4	60 T / 105 S	5.5
	Exercises			2	30 T' / 75 S	3.5
	T = face-to-face	e teaching:	S — indene	ndent study	,	'
Exam achievements	Oral exam	, waeming, i	– maeper	nacm study		aded)
Study achievements	Successful exerc	ise particip	ation		(not gr	
Forms of media	Successiui exerc	ne paracip			(1100 810	aucuj
Literature	 M. Botsch, L. Processing, A K Laga, Hamid, Mohammed Ber and applications Solomon, Just Peters/CRC Processing 	Yulan Guo Yulan Guo nnamoun. 3 s. John Wil in. Numeri	10 , Hedi Tabi D Shape ar ey & Sons,	a, Robert B nalysis: fund 2018.	3. Fisher, and	ry,

Module	Image Acqu	uisition and	l Analys	sis in N	euroscience			
MA-INF 2312	<u> </u>		T					
Workload	Credit points	Duration	Frequer	-				
180 h	6 CP	3 0						
Module	Prof. Dr. Tho	mas Schultz						
coordinator	D 4 D 50	0.1.1.						
Lecturer(s)	Prof. Dr. Tho	mas Schultz						
Classification	Programme		Mode	Semes	ter			
	M. Sc. Compu		Optional					
Technical skills	Students will					_		
					y will understa			
			,		removal, image			
	_	_			vant statistical			
			_		us will be on d			
					thematical mo	dels		
		functional and diffusion MRI data. oductive work in small teams, self-dependent solution of						
Soft skills				_				
					mage processin	0,		
			_	-	nentations, self			
	management,			nclusions	drawn from			
	complex exper							
Contents			_		nd analysis pip	eline		
	that is typical	•		,	_			
	acquisition to		sing and	statistical	l analysis.			
Prerequisites	Recommended		/ 1 1			`		
		_	(calculus,	linear alg	gebra, statistics	s);		
	imperative pro		. 1					
_	Teaching form	at Gr	oup size	h/week	Workload[h]	CP		
Format	Lecture			3	45 T / 45 S	3		
	Exercises			1	15 T / 75 S	3		
	T = face-to-fa	ce teaching;	S = indep	endent st				
Exam achievements	Oral exam				(gra	ded		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
	• B. Preim, C	. Botha: Visu	ıal Compi	iting for	Medicine: The	ory,		
	Algorithms, and	nd Application	ons. Morg	an Kaufn	nann, 2014			
	• R.A. Poldra	ck, J.A. Mun	nford, T.E	2. Nichols	: Handbook of			
Literature	Functional MRI Data Analysis. Cambridge University Press,							
	2011							
	• D.K. Jones:	Diffusion MI	RI: Theor	y, Method	d, and			
	Applications,	Oxford Unive	ersity Pres	ss, 2011				

Module MA-INF 2313	Deep Learn	ing for V	isual Re	cognitio	n		
Workload	Credit points	Duration	Freque	ency			
180 h	6 CP	1 semest	er every	year			
Module	Prof. Dr. Rein	hard Klei	1				
coordinator							
Lecturer(s)	Dr. Michael V	Veinmann					
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	ıter Scienc	e Optiona	al 1-4.			
Technical skills	Students will l	be introdu	ced to the t	heory of n	eural networks	and	
	study various AI.	application	ıs in compu	ter vision	and other topi	cs in	
Soft skills		rk in smal	l teams de	velonment	and realization	n of	
SOIT SKIIIS	individual app		,	-		11 01	
	competing me						
Contents		Deep learning has taken over the machine learning community					
Comonius					_	-	
	,	by storm, with success both in research and commercially. Deep learning is applicable over a range of fields such as computer					
	0		_		rocessing, robo		
	etc. This cour	_	*		0,	, ,	
					convolutional	and	
					in applications		
					to learn how t		
	_		_		sual recognition		
	tasks such as				_		
	caption genera	-	0 ,	0 0			
Prerequisites	Recommended						
-	Students are r	ecommend	ed to have	a basic kn	owledge in		
	probability an				_		
	proficiency in			_			
	Teaching forms		Group size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teachin	$r \cdot S = inde$	ı nendent st		1	
		oo oodoning	$_{\rm 5}, \sim -{\rm mac}$	Politically 50			
Exam achievements	, c			(gra	ded)		
Exam achievements Study achievements		rcise partic	ripation		,,,	ded)	
Study achievements		rcise partic	ripation		(gra (not gra		
	Successful exe			dings will	,,,	ded)	

Module MA-INF 2314	Image Processing, Search and Analysis I									
Workload	Credit points	Duration	Frequ	ency						
270 h	9 CP	9 CP 1 semester every year								
Module	Prof. Dr. Chr.	istian Bauc								
coordinator			J							
Lecturer(s)	Prof. Dr. Chr.	istian Bauc	khage							
	Programme		Mode	Semes	ster					
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.					
Technical skills	Upon complet:	ion, studen								
	processing • implement a	 implement basic and advanced methods for digital image processing implement simple and advanced algorithms for image filtering implement algorithms for creating artistic image effects implement algorithms for image warping implement algorithms for image morphing implement algorithms for color and intensity manipulation 								
Soft skills	processing Students will l foundations of	• design and implement their own algorithms for image processing Students will learn about the mathematical and algorithmic foundations of digital image processing and raster graphics								
	editing. They will learn about the basic concepts and procedures in this area and to implement them on their own.									
Contents	 technical for photography mathematica coordinate s Fourier trans low- band-, a mean- and C median filter efficient imp interpolation artistic imag image warpi image morph physiological color spaces color manipu 	al represent ystems and sforms and high partial and medians and medians and medians are effects and methods are effects and medians are foundation of the fo	hardware ations of coordinat convolutions filtering tering orphologicus of vario	aspects of digital image transforms g al operations kinds of	f digital ages mations ons of filters					
Prerequisites	none				I					
Format			roup size $; S = inde$	h/week 4 2 ependent s	Workload[h] 60 T / 105 S 30 T / 75 S study	5.5 3.5				
Exam achievements	Written exam			_		ided)				
Study achievements	Successful exer	rcise partic	ipation		(not gra					
Forms of media				online	(1100 810					
Torms of media	 lecture slides are made available online lecture notes with programming examples are made available online 									
Literature	Gonzales andJähne, "Digi				essing"					

Module MA-INF 2315	Seminar Computational Photography							
Workload	Credit points	Credit points Duration Frequency						
270 h	9 CP	1 semeste	r every	year				
Module	Prof. Dr. Mat	thias Hullin	'					
coordinator								
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthias Hullin						
Classification	Programme	Mode	Seme	ster				
Classification	M. Sc. Compu	M. Sc. Computer Science			2. or 3.			
Technical skills								
Soft skills								
Contents								
Prerequisites	none							
	Teaching forms	at Gı	oup size	h/week	Workload[h]	CP		
Format	Lecture			4	60 T / 105 S	5.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = inde	ependent s	study			
Exam achievements	Schriftliche Pr	üfung			(gra	ded)		
Study achievements	Erfolgreiche Ü	Erfolgreiche Übungsteilnahme (not graded)						
Forms of media								
Literature								

Module MA-INF 2316	Lab Digital Material Appearance							
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semeste	every	year				
Module	Prof. Dr. Mat	thias Hullin						
coordinator								
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthias Hullin						
Classification	Programme	Programme			ster			
Classification	M. Sc. Compu	M. Sc. Computer Science			2. or 3.			
Technical skills								
Soft skills								
Contents								
Prerequisites	none							
	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP		
Format	Lecture			4	60 T / 105 S	5.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	$S = ind\epsilon$	ependent s	study			
Exam achievements	Schriftliche Pr	üfung			(gra	ided)		
Study achievements	Erfolgreiche Ü	Erfolgreiche Übungsteilnahme (not graded)						
Forms of media								
Literature								

Module	Numerical A	_	ns for Vis	ual Cor	nputing and		
MA-INF 2317	Machine Lea						
Workload	Credit points	Duration	Frequer	-			
180 h	6 CP	1 semest		every 2	years		
Module	JunProf. Dr.	Florian B	Sernard				
coordinator							
Lecturer(s)	JunProf. Dr.	Florian B	Sernard				
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Comput		_				
Technical skills	• ability to imp			_			
	understanding		_		_		
			_	ational p	roblems in visual		
	computing and		_				
		plied for which					
	problem in visual computing and machine learning, so th						
	practical proble						
Soft skills	_	_	-	-	d utilise analogies		
	between new p		•	·			
			0	-	general intuition of		
	computational	- '	_	to adopt	different		
	perspectives of						
Contents	This module focuses on numerical methods that frequently oc						
	in the fields visual computing (VC) and machine learning (ML).						
	In addition to algorithms, this module will also cover modelling						
	aspects that are relevant for solving practical problems in VC						
	and ML. The contents include:						
	• Error analysis and conditioning of problems						
	• Linear systems (solvability, algorithms, stability,						
	regularisation), and applications and modelling in VC and ML						
	(e.g. linear reg	ression, in	nage alignme	ent, decor	nvolution)		
	• Spectral metl	hods (eige	nvalue deco	mposition	ı, singular value		
	decomposition,	respective	e algorithms	s), and th	eir applications		
	and modelling	in VC and	d ML (e.g. c	lustering,	Procrustes		
	analysis, point-	cloud alig	nment, prin	cipal com	ponents analysis)		
	_		(0		hods, second-order		
	methods, large-	scale opti	misation) ar	nd applica	ations and		
	modelling in V	C and ML	ı .				
Prerequisites	Required:						
	No formal prer	equisites.					
	Recommended:						
	Participants ar	e expected	d to have a l	nigh level	of mathematical		
	maturity (in pa	_		_			
	algebra and cal	culus is es	ssential). A	basic und	lerstanding of		
	mathematical of	ptimisatio	on is advant	ageous.			
	Teaching forma		Group size	h/week	Workload[h] CP		
Format	Lecture			2	30 T / 45 S 2.5		
	Exercises			2	30 T / 75 S 3.5		
	T = face-to-face	e teachine	$g \cdot S = indep$	endent st	, ,		
Exam achievements	Written exam		5, 5 — macp	21140110 50	(graded)		
Study achievements		cise partic	cipation		(not graded)		
Forms of media	Successful exercise participation (not graded)						
Literature							

3 Information and Communication Management

MA-INF	3108	L2E2	6 CP	Secure Software Engineering	66
$\operatorname{MA-INF}$	3109	L2E2	6 CP	Quantum Algorithms: Introduction and Data Fusion	
				Examples	67
$\mathbf{MA}\text{-}\mathbf{INF}$	3202	L2E2	6 CP	Mobile Communication	68
MA-INF	3209	Sem2	4 CP	Seminar Selected Topics in Communication	
				Management	69
$\operatorname{MA-INF}$	3215	Sem2	4 CP	Seminar Selected Topics in Malware Analysis and	
				Computer/Network Security	7 0
$\mathbf{MA}\text{-}\mathbf{INF}$	3216	Sem2	4 CP	Seminar Sensor Data Fusion	71
$\mathbf{MA}\text{-}\mathbf{INF}$	3229	Lab4	9 CP	Lab IT-Security	72
$\mathbf{MA}\text{-}\mathbf{INF}$	3233	L2E2	6 CP	Advanced Sensor Data Fusion in Distributed Systems	73
$\mathbf{MA}\text{-}\mathbf{INF}$	3235	L2E2	6 CP	Usable Security and Privacy	74
$\mathbf{MA}\text{-}\mathbf{INF}$	3236	L2E2	6 CP	IT Security	75
$\mathbf{MA}\text{-}\mathbf{INF}$	3237	L2E2	6 CP	Array Signal and Multi-channel Processing	76
$\operatorname{MA-INF}$	3238	L2E2	6 CP	Side Channel Attacks	77
$\operatorname{MA-INF}$	3239	L2E2	6 CP	Malware Analysis	78
$\operatorname{MA-INF}$	3304	Lab4	9 CP	Lab Communication and Communicating Devices	79
$\mathbf{MA}\text{-}\mathbf{INF}$	3305	Lab4	9 CP	Lab Information Systems	80
$\mathbf{MA}\text{-}\mathbf{INF}$	3309	Lab4	9 CP	Lab Malware Analysis	81
$\mathbf{MA}\text{-}\mathbf{INF}$	3310	L2E2	6 CP	Introduction to Sensor Data Fusion - Methods and	
				Applications	82
$\mathbf{MA}\text{-}\mathbf{INF}$	3312	Lab4	9 CP	Lab Sensor Data Fusion	83
$\mathbf{MA}\text{-}\mathbf{INF}$	3317	Sem2	4 CP	Seminar Selected Topics in IT Security	84
$\mathbf{MA}\text{-}\mathbf{INF}$	3319	Lab4	9 CP	Lab Usable Security and Privacy	85
$\mathbf{MA}\text{-}\mathbf{INF}$	3320	Lab4	9 CP	Lab Security in Distributed Systems	86
MA-INF	3321	Sem2	4 CP	Seminar Usable Security and Privacy	87
MA-INF	3323	Lab4	9 CP	Lab Fuzzing Bootcamp	88
MA-INF	3324	Lab4	9 CP	Lab Design of Usable Security Mechanisms	89

Module MA-INF 3108	Secure Soft	ware Eng	ineering				
	G 1:4 : 4	D 41	ъ				
Workload	Credit points	Duration	_	Frequency			
180 h	6 CP 1 semester every year						
Module	Dr. Christian Tiefenau						
coordinator	D 61	Tr. 6	f. 1 3 f .				
Lecturer(s)		Dr. Christian Tiefenau, Mischa Meier					
Classification	Programme	~ .	Mode	Semest			
	M. Sc. Compu						
Technical skills					elevant aspects	of a	
	software-engin	eering lifec	cle. There	fore, the	main ideas of		
	including secu	rity throug	nout the de	evelopmen	t process will	be	
	presented and explained by examples.						
	By showing common vulnerabilities throughout this course, the						
	students will get an understanding of common vulnerabilities						
	and attacks and how to prevent them.						
Soft skills	In groups, the students will conduct practical exercises to						
	strengthen the understanding of vulnerabilities and attack						
	vectors. Through this, the abilities teamwork, time						
	management, organization and critical discussion of their own						
	and others' re	_			sion of their ow	V 11	
Contents	• Threat mod		ciigononea.	•			
Contents	• Risk analysi	_					
	• Architectura						
	• Secure codin						
	• Applied Cry	_					
	• Secure config		d doplovm	ant			
	• Updates and	_		5116			
Duanaguisitas	Recommended		ice				
Prerequisites			n software	on gin ooni	ng and IT goay	:+	
		knowiedge	n sonware-	engmeern	ng and IT-secu	шиу	
	concepts.			1 / 1	*** 11 101	GD	
T	Teaching form	at (Froup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	S = indep	oendent st	cudy		
Exam achievements	Schriftliche Pr	_			(gra	ided)	
Study achievements	Erfolgreiche Ü	bungsteilna	hme		(not gra	ded)	
Forms of media					•	-	
Literature	Software Secu	rity: Buildi	ng Security	In by Ga	ary McGraw		

Module MA-INF 3109	Quantum Algorithms: Introduction and Data Fusion Examples							
Workload	Credit points Duration Frequency							
180 h	6 CP	1 semest	er	every y	ear			
Module	Prof. Dr. Wol	fgang Kocl	h	•				
coordinator								
Lecturer(s)	Prof. Dr. Wol	Prof. Dr. Wolfgang Koch						
Classification	Programme	Programme Mode Semester						
Classification	M. Sc. Compu	M. Sc. Computer Science			l 2. or 3	2. or 3.		
Technical skills			•					
Soft skills								
Contents								
Prerequisites	none							
	Teaching form	at	Gro	oup size	h/week	Workload[h]	CP	
Format	Lecture				2	30 T / 45 S	2.5	
	Exercises				2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	g; S	S = indep	endent st	sudy		
Exam achievements	Schriftliche Pr	üfung				(gra	ded)	
Study achievements	Erfolgreiche Ü	bungsteiln	ahr	ne		(not gra	ded)	
Forms of media								
Literature				-				

Module	Mobile Communication								
MA-INF 3202									
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP	1 semeste	r every y	ear					
Module	Prof. Dr. Pete	er Martini	•						
coordinator									
Lecturer(s)	Prof. Dr. Pete	Prof. Dr. Peter Martini, Dr. Matthias Frank							
Classification	Programme	Mode	Semes	Semester					
Classification	M. Sc. Compu	iter Science	Optiona	$1 \mid 2$. or 3	3.				
Technical skills	Knowledge ab	out key con	cepts of m	obile com	munication				
	including mob	ility manag	ement (bot	th technol	logy independe	nt			
	and technology	and technology dependent), knowledge about wireless							
	technologies and	nd their int	eraction wi	th other 1	protocol layers				
	and/or other r	network tecl	nnologies, a	ability to	evaluate and a	ssess			
	scenarios with				_				
	_		_	_	of wireless/mob				
	-	systems and network elements, productive work in small groups,							
			esentation	and discu	ssion of solution	ons			
	to current challenges								
Soft skills	Theoretical exercises to support in-depth understanding of lecture topics and to stimulate discussions, practical exercises in								
	_			, -					
			_		eted organisation				
	_				and others' resi				
Contents		_		*	ss Communicat	tion			
	Basics, Wirele		_	· ,	,				
	Communication		,	i data cor	mmunication),				
D	Ad-hoc and Se		rks.						
Prerequisites	Recommended		of bosies o	f aommun	nication system	G.			
	(e.g. BA-INF	_			·	.c.			
	, ,				nglish lecture sl	lides			
	available) and	_			_	nacs			
	Systems	/ 01 1/11/11/1	0100 1	rmerpres	or Distributed				
	Teaching forms	at C	roup size	h/week	Workload[h]	CP			
Format	Lecture		Toup Size	2	30 T / 45 S	2.5			
20211100	Exercises			$\frac{1}{2}$	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching	S — inder	I		7 3.3			
Exam achievements	Oral exam	cc tcacining	b — mac _l	ochacht st		ded)			
Study achievements	Successful exe	rcise partici	nation		(not gra				
Forms of media	Successiui exe	reise partie	pation		(1100 810	aca)			
TOTALS OF INCOME	• Jochen Schiller: Mobile Communications, Addison-Wesley,								
	2003				,	,			
	• William Stallings: Wireless Communications and Networking,								
Literature	Prentice Hall, 2002								
	· ·	• Further up-to-date literature will be announced in due course							
	before the beginning of the lecture								

Module	Seminar Selected Topics in Communication							
MA-INF 3209	Management							
Workload	Credit points	Duration	Frequency					
120 h	4 CP	1 semeste	er at lea	st every y	ear			
Module	Prof. Dr. Peter Martini							
coordinator								
Lecturer(s)	Prof. Dr. Pete	er Martini,	Prof. Dr.	Michael N	/Ieier			
Classification	Programme		Mode	Semes	ster			
	M. Sc. Compu							
Technical skills	Ability to und	Ability to understand new research results presented in original						
	scientific pape	scientific papers.						
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the						
	framework of	framework of the corresponding area.						
Contents	Current confer	ence and j	ournal pa	pers, curre	nt standardizat	ion		
	drafts							
Prerequisites	Required:							
		•			ollowing lecture	s:		
	Principles of I				, ,			
	- `	, ,		ommunicat	tion (MA-INF3	202),		
	IT Security (N							
Format	Teaching forms	at (Group size			CP		
Tormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa	ce teaching	S = ind	ependent s	tudy			
Exam achievements	Oral presentat	ion, writte	n report		(gra	ded)		
Study achievements					(not gra	$\overline{\operatorname{ded}}$		
Forms of media								
Literature	The relevant literature will be announced towards the end of the							
Literature	previous semes	ster						

Module	Seminar Selected Topics in Malware Analysis and						
MA-INF 3215	Computer/	Network S	Security				
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	1 semeste	r at least	at least every year			
Module	Prof. Dr. Peter Martini						
coordinator							
Lecturer(s)	Prof. Dr. Pete	er Martini, l	Prof. Dr. M	Iichael M	[eier		
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.		
Technical skills		Ability to understand new research results presented in original					
	scientific pape	rs.					
Soft skills					ese results in th	ne	
	framework of						
Contents				,	nt standardizat	ion	
	drafts - with a			n Malware	e Analysis,		
	Computer and	Network S	ecurity				
Prerequisites	Required:						
		•			llowing lecture	s:	
	Principles of I		•		, ,		
	- '	, .		nmunicati	ion (MA-INF32	202),	
	IT Security (N		/		1		
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
	Seminar		10	2	30 T / 90 S	$\mid 4 \mid$	
	T = face-to-fa	ce teaching;	S = indep	endent st	cudy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 3216	Seminar Sensor Data Fusion							
Workload	Credit points Duration Frequency							
120 h	4 CP	4 CP 1 semester every year						
Module	P.D. Dr. Wolfgang Koch							
coordinator								
Lecturer(s)	P.D. Dr. Wolf	gang Koch						
Classification	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optiona	ıl 2.				
Technical skills	Ability to und	Ability to understand new research results presented in original						
	scientific pape	scientific papers.						
Soft skills	Ability to pres	sent and to	critically of	liscuss the	ese results in th	ne		
	framework of	the correspond	onding area	a.				
Contents	Current confer	ence and jo	ournal pap	ers				
Prerequisites	none							
Format	Teaching forms	at (Group size	h/week	Workload[h]	CP		
Format	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa	ce teaching	$S = inde_{I}$	pendent st	udy			
Exam achievements	Oral presentat	ion, writter	report		(gra	ded)		
Study achievements					(not gra	ded)		
Forms of media								
Literature	The relevant li seminar.	terature wi	ll be anno	inced at t	he beginning o	f the		

Module	Lab IT-Security						
MA-INF 3229							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	1 semester every semester				
Module	Prof. Dr. Michael Meier						
coordinator							
Lecturer(s)	Prof. Dr. Mic.	hael Meier					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.		
Technical skills	The students	The students will carry out a practical task (project) in the					
	context of IT Security, including test and documentation of the						
	implemented s	oftware/sys	em.				
Soft skills	Ability to prop	perly presen	and defe	nd design	n decisions, to		
	prepare readal	ole documen	tation of	software;	skills in		
	constructively	collaboratin	g with ot	hers in sr	nall teams over	a	
	longer period	of time; abil	ty to clas	sify ones	own results into	o the	
	state-of-the-ar	t of the resp	. area				
Contents							
Prerequisites	none						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Format	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ided)	
Study achievements					(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature							

Module	Advanced Sensor Data Fusion in Distributed								
MA-INF 3233	Systems								
Workload	Credit points	Duration	Freque	ıcy					
180 h	6 CP								
Module	PD Dr. Wolfg	PD Dr. Wolfgang Koch							
coordinator									
Lecturer(s)	Dr. Felix Govaers								
Classification	Programme	\mathbf{Mode}	Semes	ter					
Classification	M. Sc. Compu		Optiona						
Technical skills					hms which enh	ance			
	the situational								
		inevitable. Nowadays it has become very popular to improve the							
	_	performance of systems by linking multiple sensors. This implies some challenges to the sensor data fusion methodologies such as							
	_								
	sensor registration, communication delays, and correlations of estimation errors. In particular, if the communication links ha								
		limited bandwidth, data reduction techniques have to be appl							
	at the sensor sites, that is local tracks have to be computed. Once recieved at a fusion center (FC), the tracks then are fus to reconstruct a global estimate. In this lecture, methodologi								
		0			, .	;ies			
	to a achieve a distributed state estimation are considered. Among these are tracklet fusion, the Bar-Shalom-Campo								
	formula, the Federated Kalman Filter, naive fusion, the								
	distributed Kalman filter and the least squares estimate.								
Soft skills	Mathematical								
	mathematical		_						
Contents					ıla, the Federat	ted			
	Kalman Filter, naive fusion, the distributed Kalman filter and								
	the least squar	res estimate,	Accumula	ated State	e Densities,				
	Decorrlated fu	sion, produc	t represen	tation					
Prerequisites	Recommended	:							
	At least 1 of the	he following:							
	BA-INF 137 –	Einführung	in die Ser	sordaten	fusion				
	MA-INF 3310	– Introducti	on to Sens	sor Data	Fusion - Metho	ods			
	and Application								
	Teaching forma	at G	oup size	h/week	Workload[h]	CP			
Format	Lecture			2	30 T / 45 S	2.5			
	Exercises			2	30 T / 75 S	3.5			
	T = face-to-face teaching; S = independent study								
Exam achievements	Oral exam	<u> </u>	r			ded)			
Study achievements	Successful exer	rcise particip	ation		(not gra				
Forms of media	Power Point				<u> </u>				
	W. Koch: "Tra	acking and S	ensor Dat	a Fusion:	Methodologica	al			
	Framework an	_			_				
Literature	D. Hall, CY. Chong, J. Llinas, and M. L. II: "Distributed Data								
	D. Hall, UY.	Chong. J. L	linas, and	M. L. II:	"Distributed I	Jata			

Module MA-INF 3235	Usable Secur	rity and F	Privacy				
Workload		Duration	Frequer	ncy			
180 h		1 semester	every y	ear			
Module	Prof. Dr. Matt	hew Smith					
coordinator	_						
Lecturer(s)	Prof. Dr. Matthew Smith						
Classification	Programme Mode Semester M. C. Grammaton Crimes Outlined 1						
m 1 · 1 1·11	M. Sc. Comput		Optional		ma of IT assum	:4	
Technical skills	Students will be and privacy me usability of IT s able to design a	chanisms, u security and	nderstand privacy 1	l methods mechanisr	for exploring		
Soft skills	• Working with		terature				
	Communication						
	• Team working	*					
Contents	The lecture on				·		
	aspects of human factors and usability in the context of securi and privacy. The lecture includes both the foundations of usal security and privacy as well as a selection of cutting edge international research in this area. Topics include:						
	• Evaluation of usability issues of existing security & privacy models or technology						
	• Design and ev	aluation of	new usab	le securit	y & privacy		
	technology						
	• Impact of org	anizational	policy on	security a	and privacy		
	interaction	1.6. 1					
	• Lessons learne		0 0,		nanaging or		
	evaluating secur		· ·	_			
	Foundations of Methodology				rosoprah		
	• Ethical, psych		-			f	
	security & prive		_	and econ	onne aspects o	1	
Prerequisites	Required:		/810b				
Trerequisives	Knowledge about IT Security is advantageous but not mandatory.						
	Recommended:						
	At least 1 of the	e following:					
	BA-INF 138 – I		t				
	BA-INF 136 – I						
	MA-INF 1103 -						
	MA-INF 3229 –			h /wools	Workload[h]	CD	
Format	Teaching format Lecture	Gr	oup size	h/week	30 T / 45 S	2.5	
1 31 IIIau	Exercises			$\frac{2}{2}$	30 T / 45 S 30 T / 75 S	3.5	
		topobiese (0.0	
Every cobi	T = face-to-face Written exam	e teacning;	5 = indep	enaent st		ded)	
Exam achievements Study achievements	Successful exerc	ica narticin	ation		(gra (not gra		
Forms of media	Puccessini exelt	ne harmerb	auton		(not gra	aeu)	
Literature							
Literature							

Module	IT Security								
MA-INF 3236	C	D4:	Th						
Workload 180 h	Credit points 6 CP	Duration 1 semeste	Frequency						
	6 CP 1 semester every year Prof. Dr. Michael Meier								
Module	Prof. Dr. Mici	naei Meier							
coordinator	D C D M: 1 1M:								
Lecturer(s)		Prof. Dr. Michael Meier							
Classification	Programme		Mode	Semest					
	M. Sc. Compu		Optional						
Technical skills					earch fields of l	lΤ			
		security and gain deep knowledge of the research literature.							
		Students learn selected aspects of IT security. This includes							
		risks and vulnerabilities of today's information technology as							
	well as concepts to increase the level of IT security, their								
	applications and their weaknesses.								
Soft skills	Theoretical exercises to support in-depth understanding of								
	lecture topics	and to stime	ılate discu	ssions, pr	actical exercise	es in			
					eted organization				
	practical work	and critical	discussion	n of own a	and others' resu	ults.			
Contents	• security thre	eats							
	• advanced ne	twork securi	ty: interne	et routing	security, netw	ork			
	attack detection	on, network	informatio	n hiding					
	• cryptographi	ic key mana	gement						
	• building auto	omation sec	urity						
	• advanced ho	st security							
	• security patt	erns							
	• privacy and	pseudonymi	zation						
Prerequisites	Required:								
	Fundamental l	knowledge ii	the follow	ving areas	s: operating				
	systems, netwo	orks, securit	У						
	Teaching forms		roup size	h/week	Workload[h]	CP			
Format	Lecture		_	2	30 T / 45 S	2.5			
	Exercises			2	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching:	S = index			ı			
Exam achievements	Written exam	ce reacting,	5 — muep	chacht St		ded)			
Study achievements	Successful exer	rcisa partici	nation		(not gra				
Forms of media	Successiui exei	reise partier	Janon		(not gra	ueu)			
Literature									

Module MA-INF 3237	Array Signa	al and Mul	ti-chann	el Proc	essing				
Workload	Credit points	Duration	Frequen	cy					
180 h	6 CP	1 semester	er every year						
Module	Prof. Dr. Wol	fgang Koch	'						
coordinator									
Lecturer(s)	Dr. Marc Oisp	ouu							
Classification	Programme Mode Semester				ter				
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.				
Technical skills	Localization of	Localization of multiple sources using passive sensors is a							
	fundamental t	fundamental task encountered in various fields like wireless							
	communication	n, radar, son	ar, and sei	smology.	In this lecture, a				
	unified framew	vork for elect	romagneti	c and acc	oustic signals and				
	signal processi	ng technique	s are prese	ented. Fu	irthermore, the				
	sensor calibrat	sensor calibration, direction finding, and bearings-only							
	localization pr	oblem are co	nsidered.	Special a	pplications are				
	emphasized, li	ke small airb	orne array	s for unr	nanned aerial				
	vehicles (UAVs	vehicles (UAVs).							
Soft skills	Mathematical	derivation of	algorithm	s, applic	ations of				
	mathematical	results on es	timation t	heory					
Contents	Estimation the	eory, Sensor	model, Cra	amér-Rac	analysis,				
	conventional b	eamforming,	Multiple	Signal Cl	lassification				
	(MUSIC), sens	sor calibration	n, Bearing	s-only lo	calization, Direct				
	Position Deter	mination (D	PD), Appl	ications					
Prerequisites	Recommended	:							
	Recommended	l: F. Kurth:	"Foundati	ons of Au	ıdio Signal				
	Processing" (N								
	Teaching forms	at G1	oup size	h/week	Workload[h] CP				
Format	Lecture			2	30 T / 45 S 2.5				
	Exercises			2	30 T / 75 S 3.5				
	T = face-to-fa	ce teaching;	S = indep	endent st	cudy				
Exam achievements	Oral Exam				(graded)				
Study achievements	Successful exe	rcise particip	ation		(not graded)				
Forms of media	Power Point								
	H. L. van Tree	es, Optimum	Array Pro	cessing.	Part IV of				
Literature	Detection, Est	imation, and	Modulati	on Theor	ry. New York:				
	Wiley-Interscie	ence, 2002.							

Module MA-INF 3238	Side Chann	el Attack	S					
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semeste	r every year					
Module	Dr. Felix Boes	}	1					
coordinator								
Lecturer(s)	Dr. Felix Boes							
Classification	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	iter Science	Optiona	l 2. or 3	3.			
Technical skills	• Students are	• Students are introduced to theoretical and practical side						
	channel effects	of modern	hardware.					
	• Students lear	• Students learn techniques to utilize these effects to circumvent						
	security mecha	misms.						
	• This include	s covert cha	nnels as w	ell as side	channel attac	ks		
	and microarchitectural attacks on modern CPUs.							
Soft skills	Theoretical exercises to support in-depth understanding of							
	lecture topics and to stimulate discussions, practical exercises in							
	teamwork to s	upport tim	e managem	ent, targe	eted organization	on of		
	practical work	and critica	l discussion	n of own a	and others' resu	ults.		
Contents	• Theoretical f	foundations	of side cha	annel effec	cts and attacks	as		
	well as							
	• covert chann	els,						
	• differential p		sis,					
	• padding orac	ele,						
	• RSA timing	attacks,						
	• cache based	side channe	el effects,					
	• microarchite	ctural atta	ks (Spectr	e)				
Prerequisites	Recommended	:						
	Fundamental l	knowledge a	bout IT Se	ecurity, op	perating system	ns		
	and statistics i	is advantag	eous but no	ot mandat	tory.			
	Teaching forma	at (roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching	S = inder	endent st	udy			
Exam achievements	Written Exam		1			ded)		
Study achievements	Erfolgreiche Ü		hme		(not gra			
Forms of media					, 0			
Literature								

Module	Malware An	nalysis							
MA-INF 3239		v							
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP	1 semester	every se						
Module	Prof. Dr. Peter	Martini	•						
coordinator									
Lecturer(s)	Prof. Dr. Elmar Padilla								
Classification	Programme		\mathbf{Mode}	Semester					
		M. Sc. Computer Science Optional 2. or 3.							
Technical skills	The students sh				-				
	binary file indep				~ -				
	addition, the students should be able to carry out detailed ana given aspects and to partially automate these with the help of								
Soft skills	Presentation of								
SOIL SKIIIS	methods and te		i memous	, critical dis	cussion of appir	eu			
Contents	In the course, the deepened and as Different malware author	ne skills acqu dapted to the re samples ar s. These price	e peculiari re used to prities inclu	ties of malw explain the	are analysis.				
	Characteristics of malwarePersistence								
	Network communication								
	• Encryption								
	Dynamic malware analysis								
	• Debugging								
	Behavioral obfuscationVirtual analysis environments								
	• Static malwar		ents						
	• Control flow of								
	• Automation o		alvsis ster	os					
	• Reconstruction								
	The event begins with several lectures that provide the basics for the								
	students to worl			-		one			
	students will wo								
	analysis during					out to			
	be very specific,	it is necessa	ry to be w	villing to dea	al with the subj	ect			
	outside of the le	ecture and ex	ercise time	es.					
Prerequisites	Required:								
	none								
	Recommended			(1 1 -					
	Basic knowledge								
	memory), netwo					гу			
	analysis (assemble development (pr				- /				
	Teaching forma		roup size		Workload[h]	CP			
Format	Lecture	G	Toup Size	2	30 T / 45 S	2.5			
	Exercises			$\frac{2}{2}$	30 T / 75 S	$\frac{2.5}{3.5}$			
	T = face-to-face	toaching C	- indeper	1	,	1			
Exam achievements	$\Gamma = 1ace-to-1ace$ Oral exam	e teaching; 5	— maeper	ideni study	(ore	aded)			
Study achievements	Orai Cami				(gr	aucuj			
	Successful ever	ise particinat	ion		(not gre	aded)			
-	Successful exerc	ise participat	tion		(not gra	aded)			
Forms of media Literature	Successful exerce The relevant lite			ced at the b	, ,	aded)			

Module	Lab Commi	ınication	and Co	mmunic	ating Devices	\mathbf{s}		
MA-INF 3304								
Workload	Credit points	Duration	Frequ	Frequency				
270 h	9 CP	1 semest	er every	every semester				
Module	Prof. Dr. Pete	Prof. Dr. Peter Martini						
coordinator								
Lecturer(s)	Prof. Dr. Pete	er Martini,	Prof. Dr.	Michael I	Meier			
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.			
Technical skills	The students	The students will carry out a practical task (project) in the						
	context of communication systems, including test and							
	documentation	locumentation of the implemented software/system.						
Soft skills	Work in small	Work in small teams and cooperate with other teams in a group;						
	ability to make design decisions in a practical task; present and							
	discuss (interi	discuss (interim and final) results in the team/group and to						
		; prepare v	ritten do	cumentation cume	on of the work			
	carried out							
Contents	Selected topics							
	communication	-			obile			
	communication	n and com	nunicating	g devices.				
Prerequisites	Required:							
		-			ollowing lecture	s:		
	_				3105), Network			
				ommunica	tion (MA-INF32	202),		
	IT Security (N							
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
2 02 2220	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching	S = I = I = I = I = I = I = I = I = I =	ependent s	study			
Exam achievements	Oral presentat	ion, writte	n report		(gra	ded)		
Study achievements					(not gra	ded)		
Forms of media								
Literature	The relevant l	iterature w	ill be anno	ounced to	wards the end o	f the		
Literature	previous semes	ster.						

Module MA-INF 3305	Lab Information Systems						
Workload	Credit points	Duration	Freque	encv			
270 h	9 CP	1 semester					
Module	Dr. Thomas Bode						
coordinator							
Lecturer(s)	Dr. Thomas E	Bode					
Classification	Programme		Mode	Seme	Semester		
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	2. or 3.		
Technical skills	The students v	The students will carry out a practical task (project) in the					
	context of information systems, including test and						
	documentation of the implemented software/system.						
Soft skills	Ability to properly present and defend design decisions, to						
	prepare readal			,			
	·	`			nall teams over		
	· .			ssify ones	own results into	the the	
	state-of-the-ar						
Contents		_			rch in the area	of	
	database- and	information	systems.				
Prerequisites	none						
Format	Teaching forms	at Gro	up size	h/week	Workload[h]	CP	
Tormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	The relevant li		be anno	ounced to	wards the end o	f the	

Module MA-INF 3309	Lab Malware Analysis								
Workload	Credit points	Duration	Freque	Frequency					
270 h	9 CP	1 semester	every	semester					
Module	Prof. Dr. Pete	Prof. Dr. Peter Martini							
coordinator									
Lecturer(s)	Prof. Dr. Pete	er Martini, F	rof. Dr.	Michael I	Meier				
Classification	Programme		Mode	Seme	ster				
Classification	M. Sc. Compu	iter Science	Optiona	al 3.					
Technical skills	The students v	The students will carry out a practical task (project) in the							
	context of con	context of communication systems with a specific topic focus on							
	Malware Analysis and Computer/Network Security, including								
		test and documentation of the implemented software/system.							
Soft skills		Work in small teams and cooperate with other teams in a group;							
		_		-	l task; present a	and			
	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	,			n/group and to				
		; prepare wr	itten doc	umentati	on of the work				
	carried out			1					
Contents	Selected topics								
	communication		ialware a	nalysis, co	omputer and				
—	network securi	ty.							
Prerequisites	Required:	1-4:£	. 14	£ +1 £	-11				
		_			ollowing lecture	s:			
	Principles of I		` `		tion (MA-INF3:	202)			
	IT Security (MA-	, ,		mmumca	uon (MA-INF)	202),			
D	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP			
Format	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching;	S = inde	pendent s	study				
Exam achievements	Oral presentat	ion, written	report		(gra	ded)			
Study achievements					(not gra	ded)			
Forms of media									
Literature									

Module			or Data	Fusion -	Methods a	nd					
MA-INF 3310	Application										
Workload	Credit points	Duration	Freque	-							
180 h	6 CP 1 semester every year										
Module	P.D. Dr. Wolf	gang Koch									
coordinator											
Lecturer(s)		P.D. Dr. Wolfgang Koch									
Classification	Programme		Mode	Semes	ter						
	M. Sc. Compu		_								
Technical skills		_			theory of senso						
				-	ries on how to						
			_		analytical calcı						
	· · · · · · · · · · · · · · · · · · ·				an filter is deri						
		_			aches to a wide						
	_	_			lgorithms will	be					
	motivated by	_	_								
	industrial cooperations, and impressions of current										
	demonstration hardware.										
	Because of inherent practical issues, every sensor measures										
	certain properties up to an error. This lecture shows how to										
	model and overcome this error by an application of theoretical										
	tools such as Bayes' rule and further derivations. Moreover,										
	solutions to possible false-alarms, miss-detections, maneuvering										
	phases, and m				,	O					
Soft skills	Mathematical				eation of						
	mathematical										
Contents					an filter.						
	Gaussian probability density functions, Kalman filter, Multi-Hypothesis-Trackier, Interacting Multiple Model Filter,										
	Retrodiction, Smoothing, Maneuver Modeling										
Prerequisites	none	0	<u>'</u>		,						
	Teaching forms	at	Group size	h/week	Workload[h]	СР					
Format	Lecture			2	30 T / 45 S	2.5					
20111111	Exercises			$\frac{2}{2}$	30 T / 75 S	3.5					
		41-:	. C : 1	I		1 0.0					
T. 11	T = face-to-fa	ce teacning	s = indep	pendent st		1. 1\					
Exam achievements	Written exam	•	• ,•			$\frac{\text{ded}}{1}$					
Study achievements	Successful exe	rcise partic	ipation		(not gra	aea)					
Forms of media	117 TZ 1 UCC	1. 1	0 5	Т.	3.6.1.1.1.	1					
					Methodologica	al					
Literature	Framework an	d Selected	Application	ns", Spring	ger, 2014.						
	Y. Bar-Shalon	n: "Estimat	ion with A	pplication	s to Tracking a	and					
	Navigation", V	Viley-Inters	science, 200	1.	Y. Bar-Shalom: "Estimation with Applications to Tracking and Navigation", Wiley-Interscience, 2001.						

Module MA-INF 3312	Lab Sensor Data Fusion						
Workload	Credit points	Duration	n	Freque	ency		
270 h	9 CP	1 semes	ster	every	year		
Module	P.D. Dr. Wolf	gang Koc	h				
coordinator							
Lecturer(s)	P.D. Dr. Wolf	gang Koc	h				
Classification	Programme			Mode	Seme	Semester	
Classification	M. Sc. Compu	iter Scien	ce	Optiona	al 3.		
Technical skills	The students will work together on a data fusion project using						
	various sensor hardware. Latest algorithms for fusing						
	information from several nodes will be implemented.						
Soft skills	The students s	The students shall work together in a team. Everyone is					
	responsible for	a specifi	c pa	rt in the	e context	of a main goal.	
	Results will be	e exchang	ed a	nd integ	grated via	software interfa	aces.
Contents	Varying select	ed topics	on s	sensor da	ata fusion		
Prerequisites	none						
Format	Teaching forms	at	Gro	up size	h/week	Workload[h]	CP
rormat	Lab			8	4	60 T / 210 S	9
	T = face-to-fa	ce teachir	ng; S	S = inde	pendent s	study	
Exam achievements	Oral presentat	ion, writt	ten r	eport		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature	The relevant li	iterature ·	will	be anno	unced at	the beginning o	f the
	lab.						

Module MA-INF 3317	Seminar Selected Topics in IT Security							
Workload	Credit points	Credit points Duration Frequency						
120 h	4 CP	4 CP 1 semester every year						
Module	Prof. Dr. Mich	Prof. Dr. Michael Meier						
coordinator								
Lecturer(s)	Prof. Dr. Mich	Prof. Dr. Michael Meier, Prof. Dr. Peter Martini						
Classification	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	ter Science	Optional	2.	$\mid 2.$			
Technical skills	Ability to unde	Ability to understand new research results presented in original						
	scientific paper	scientific papers.						
Soft skills	Ability to pres	ent and to c	ritically di	scuss the	ese results in th	ie –		
	framework of t	he correspon	nding area	•				
Contents	Current confer	ence and jou	rnal pape	rs				
Prerequisites	none							
Format	Teaching forma	ıt Gı	oup size	h/week	Workload[h]	CP		
rormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fac	ce teaching;	S = indep	endent st	udy			
Exam achievements	Oral presentati	ion, written	report		(gra	ded)		
Study achievements					(not gra	ded		
Forms of media								
Literature								

Module MA-INF 3319	Lab Usable Security and Privacy							
Workload	Credit points	Duration	Freque	ncy				
270 h	9 CP	9 CP 1 semester every year						
Module	Prof. Dr. Mat	thew Smith	-1					
coordinator								
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthew Smith						
Classification	Programme		Mode	Semes	ster			
Classification	M. Sc. Compu	iter Science	Optiona	d 2.				
Technical skills	The students	The students will carry out a practical task (project) in the						
	context of usable security and privacy, including user studies.							
Soft skills	Ability to crea	Ability to create and defend a scientific user study						
Contents	Students have	Students have a great degree of freedom to chose their own						
	topics within t	the context of	f human	aspects o	f security and			
	privacy.							
Prerequisites	Required:							
	MA-INF 3235	- Usable Sec	curity and	d Privacy				
Format	Teaching forms	at Gre	oup size	h/week	Workload[h]	CP		
Tormat	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching;	S = indep	pendent s	study			
Exam achievements	Oral presentat	tion, written	report		(gra	ded)		
Study achievements					(not gra	ded)		
Forms of media								
Literature								

Module MA-INF 3320	Lab Securit	y in Distri	buted S	ystems	3			
Workload	Credit points	Duration	Freque	ncy				
270 h	9 CP	1 semester	r every year					
Module	Prof. Dr. Mat	thew Smith						
coordinator								
Lecturer(s)	Prof. Dr. Mat	thew Smith						
CI :C ::	Programme		Mode	Seme	ster			
Classification	M. Sc. Computer Science Optional 2.							
Technical skills	The students	will carry ou	a practio	cal task	(project) in the			
	context of dist	ributed secu	rity, inclu	ding doc	umentation of	the		
	implemented s			J				
	Strong progra	mming skills	required					
Soft skills		Strong programming skills required. Ability to properly present and defend design decisions, to						
Soft Skills		prepare readable documentation of software; skills in						
				,	mall teams over	я		
			_		own results int			
	state-of-the-ar		-	only ones	OWII Tesaites inte	O the		
Contents	Security in dis			ıding an	nongst others:			
Contents		· ·	ome, men	adiiig dii	1011850 0011015.			
	• Secure Mess	0 0						
	• App Security							
	• SSL/HTTPS							
	API Security Machine Lea	•						
	Machine LeaPasswords	arning for Sec	curity					
		C						
	• Intrusion De	-	ems					
	• Anomaly De							
D 111	• Security Vis	ualisation						
Prerequisites	none			. / .	*** 11 101	GD		
Format	Teaching forms	at Gro	-	h/week	Workload[h]	CP		
	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa			endent s				
Exam achievements	Oral presentat	tion, written	report		,-	aded)		
Study achievements					(not gra	aded		
Forms of media								
Literature								

Module MA-INF 3321	Seminar Us	Seminar Usable Security and Privacy					
Workload	Credit points	Duration	n Frequency				
120 h	4 CP						
Module	Prof. Dr. Mat	Prof. Dr. Matthew Smith					
coordinator							
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthew Smith					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	2.			
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	scientific papers.					
Soft skills	Ability to pres	sent and to c	ritically di	scuss the	se results in th	ne	
	framework of	the correspon	nding area.				
Contents	Current confer	rence and jou	ırnal pape	rs.			
Prerequisites	none						
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = independent S	endent st	udy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module	Lab Fuzzing	g Bootca	mp				
MA-INF 3323							
Workload	Credit points	Duration	Fre	Frequency			
270 h	9 CP	9 CP 1 semester every year					
Module	Prof. Dr. Mat	thew Smit	h				
coordinator							
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthew Smith					
Classification	Programme		Mod	e	Semes	ster	
Classification	M. Sc. Compu	iter Scienc	e Opti	onal	2. or	3.	
Technical skills	The students	The students will carry out a practical task (project) in the					
	context of fuzz	context of fuzz testing, including test and documentation of the					
	implemented software/system.						
Soft skills	Ability to prop	perly prese	nt and	defend	d design	decisions, to	
	prepare readal	ole docum	entation	of so	ftware;	skills in	
	constructively	collaborat	ing with	othe	ers in sn	nall teams over	a
	longer period	of time; ab	ility to	classif	fy ones	own results into	o the
	state-of-the-ar	t of the re	sp. area				
Contents							
Prerequisites	none						
T3 4	Teaching forms	at (Group siz	ze h	/week	Workload[h]	CP
Format	Lab		8		4	60 T / 210 S	9
	T = face-to-fa	ce teachin	g; S = in	ndepe	ndent s	study	
Exam achievements	Oral presentat	ion, writte	n repor	t		(gra	ided)
Study achievements						(not gra	ided)
Forms of media							
Literature							

Module	Lab Design	of Usab	e Secur	ity I	Mech	anisms	
MA-INF 3324							
Workload	Credit points	Duration	Frequ	ıency	r		
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Mat	thew Smit	h				
coordinator							
Lecturer(s)	Dr. Emmanue	Dr. Emmanuel von Zezschwitz					
Classification	Programme		Mode		Semes	ster	
Classification	M. Sc. Compu	iter Scienc	e Option	nal	2. or	3.	
Technical skills	The students	The students will carry out a practical task (project) in the					
	context of usa	context of usable security mechanisms, including test and					
	documentation of the implemented software/system.						
Soft skills	Ability to prop	perly prese	nt and de	fend	design	decisions, to	
	prepare readal	ble docume	entation o	f soft	ware;	skills in	
	constructively	collaborat	ing with o	others	s in sn	nall teams over	a
	longer period	of time; ab	ility to cla	assify	ones	own results into	o the
	state-of-the-ar	t of the res	sp. area				
Contents							
Prerequisites	none						
Format	Teaching forms	at C	roup size	h/	week	Workload[h]	CP
rormat	Lab		8		4	60 T / 210 S	9
	T = face-to-fa	ce teaching	g; S = ind	lepen	dent s	study	
Exam achievements	Oral presentat	tion, writte	n report			(gra	ded)
Study achievements		<u> </u>				(not gra	ded
Forms of media							
Literature							

4 Intelligent Systems

MA-IN	F 4111	L2E2	6 CP	Intelligent Learning and Analysis Systems: Machine Learning	. 91
MA-IN	F 4112	L2E2	6 CP	Intelligent Learning and Analysis Systems: Data Mining and	
				Knowledge Discovery	. 92
MA-IN	F 4113	L2E2	6 CP	Cognitive Robotics	. 93
MA-IN	F 4114	L2E2	6 CP	Robot Learning	. 94
MA-IN	F 4201	L2E2	6 CP	Artificial Life	. 95
MA-IN	F 4203	L2E2	6 CP	Autonomous Mobile Systems	. 96
MA-IN	F 4204	L2E2	6 CP	Technical Neural Nets	. 97
MA-IN	F 4207	L2E2	6 CP	Dynamically Reconfigurable Systems	. 98
MA-IN	F 4208	Sem2	4 CP	Seminar Vision Systems	. 99
MA-IN	F 4209	Sem2	4 CP	Seminar Principles of Data Mining and Learning Algorithms	100
MA-IN	F 4210	Sem2	4 CP	Seminar Advanced Topics in Technical Informatics	101
MA-IN	F 4211	Sem2	4 CP	Seminar Cognitive Robotics	
MA-IN	F 4215	L2E2	6 CP	Humanoid Robotics	103
MA-IN	F 4216	L2E2	6 CP	Data Mining and Machine Learning Methods in Bioinformatics	104
MA-IN	F 4217	Sem2	4 CP	Seminar Machine Learning Methods in the Life Sciences	
MA-IN	F 4226	Lab4	9 CP	Lab Parallel Computing for Mobile Robotics	
MA-IN	F 4228	L4E2	9 CP	Foundations of Data Science	107
MA-IN	F 4229	L4E2	9 CP	Pattern Recognition (1)	108
MA-IN	F 4230	L2E2	6 CP	Advanced Methods of Information Retrieval	
MA-IN	F 4231	Sem2	4 CP	Seminar Advanced Topics in Information Retrieval	
MA-IN	F 4232	Lab4	9 CP	Lab Information Retrieval in Practice	
MA-IN	F 4302	L2E2	6 CP	Advanced Learning Systems	
MA-IN	F 4303	L2E2	6 CP	Learning from Non-Standard Data	
MA-IN				Lab Cognitive Robotics	
MA-IN	F 4306	Lab4		Lab Development and Application of Data Mining and Learning	
				Systems	
MA-IN	F 4307	Lab4	9 CP	Lab Field Programmable Gate Arrays	116
				Lab Vision Systems	
MA-IN	F 4309	Lab4	9 CP	Lab Sensor Data Interpretation	118
MA-IN	F 4310	Lab4	9 CP	Lab Mobile Robots	119
MA-IN	F 4312	L2E2	6 CP	Semantic Data Web Technologies	120
MA-IN	F 4313	Sem2	4 CP	Seminar Semantic Data Web Technologies	121
MA-IN	F 4314	Lab4	9 CP	Lab Semantic Data Web Technologies	
MA-IN	F 4316	L2E2	6 CP	Graph Representation Learning	
MA-IN	F 4318	Sem2	4 CP	Seminar Representation Learning for Big Data Analytics	124
MA-IN				Game AI	
MA-IN	F 4320	Lab4	9 CP	Lab Representation Learning on Graphs	126
				Seminar Learning from Time Series	
				Lab Machine Learning on Encrypted Data	
				Pattern Recognition (2)	
				Seminar Advanced Topics in Data Science	
MA-IN	F 4325	Lab4	9 CP	Lab Data Science in Practice	131
MA-IN	F 4326	L2E2		Explainable AI and Applications	
MA-IN	F 4327	Lab4		Lab Biomedical Data Science	
MA-IN	F 4328	L2E2	6 CP	Spatio-Temporal Data Analytics	134
MA-IN	F 4329	Sem2	4 CP	Seminar Biological Intelligence	135

Module MA-INF 4111	Intelligent I Learning	Learning a	nd Anal	lysis Sys	stems: Mach	ine			
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP	1 semester	every y	ear					
Module	Prof. Dr. Stefa	an Wrobel	•						
coordinator									
Lecturer(s)	Prof. Dr. Stefa	an Wrobel							
Classification	Programme		Mode	Semes	ter				
Classification	M. Sc. Compu		Optiona						
Technical skills	This module is		-						
	students gain a		_		_				
	paradigms and		_	_	, ,	ey			
		re used in data analysis and/or for implementing adaptive							
	,	ehaviour (machine learning, data mining, knowledge discovery							
	· /	databases). This module concentrates on the core task of							
	_	redictive learning from examples and on agent learning, and eaches the main classes of algorithms for these tasks. At the							
		aches the main classes of algorithms for these tasks. At the							
		propriate methods and systems for particular predictive							
		arning applications and use them to arrive at convincing							
		sults, and will know where to start whenever adaptation or							
	· · · · · · · · · · · · · · · · · · ·	Fhis module complements MA-INF 4112 and can be taken							
	_								
	before or after	_							
Soft skills	Communicativ	e skills (oral	and write	ten presen	ntation of solut	ions,			
	discussions in	•		_					
	and formulate	criticism, al	oility to an	nalyze pro	blems)				
Contents	Types of learn	_	•	*	-				
	non-parametri	-			•	ning			
	(e.g., decision								
	neighbourhood								
	approaches), re	einforcement	learning,	evaluatio	on and learning	5			
.	theory.								
Prerequisites	Required:	Intalliment	Laamaina	and Anal	regia Creat arms la	0.5			
	MA-INF 4102 not been passe	_	Learning	and Anai	lysis Systems n	as			
	_								
	Recommended		.1., .1	1.	1.1	1			
	Prior knowleds	-			· ,	aı			
	intelligence, in				1	CD			
Format	Teaching forma Lecture	ու G:	roup size	h/week	Workload[h] 30 T / 45 S	2.5			
rormat	Exercises			$\frac{2}{2}$	30 T / 45 S	$\begin{vmatrix} 2.3 \\ 3.5 \end{vmatrix}$			
			Q : 1	I	,	0.0			
T2 1.	T = face-to-face	ce teaching;	s = inder	pendent st		المال			
Exam achievements	Written exam	raiga narticir	ntion		,-	$\frac{\text{ded}}{\text{dod}}$			
Study achievements Forms of media	Successful exercises Lectures, exercises)G	(not gra	ueu)			
rorms or media	- Tom Mitchel				Hill 1997				
T it anat									
Literature	- Ian Witten, l	Libe Frank,	Data Min	ing, Morg	an Kauffmann	,			
	2000								

Module MA-INF 4112	Intelligent I Mining and				stems: Data			
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semester	every y	rear				
Module	Prof. Dr. Stef	an Wrobel	·					
coordinator								
Lecturer(s)	Prof. Dr. Wro	bel						
Classification	Programme		Mode	Semes				
	M. Sc. Compu		Optiona					
Technical skills	This module is		-	·				
	students gain a		_		_			
	paradigms and		_	_	, ,	ey		
	are used in da		,	-				
	behaviour (ma in databases).				_	-		
	pattern discov							
	algorithms for	-						
	module, studer	,				UIIC		
	methods and s		_	_				
	applications ar			-		ıd		
	will know whe							
		development of algorithms and systems is necessary. This						
	module comple	_	=		=	or		
	after that mod							
Soft skills	Communicativ	e skills (ora	and writt	en presen	ntation of solut	ions,		
	discussions in	small teams), self com	petences	(ability to acce	$_{ m ept}$		
	and formulate	criticism, al	oility to ar	nalyze pro	oblems)			
Contents	Types of learn	_	•	,				
	descriptive dat					os,		
	clustering, pre				- '			
	warehouses, O	, , =				xt,		
	multimedia da	ta), interact	ive and vi	sual syste	ems.			
Prerequisites	Required:	T . 111	т.					
	MA-INF 4102	_	Learning	and Anal	lysis Systems h	as.		
	not been passe	ea.						
	Recommended		.1.	1.	1 1	,		
	Prior knowleds		-		_	al		
	intelligence, in					~-		
TD 4	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture Exercises			$\frac{2}{2}$	30 T / 45 S	2.5		
		_			30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	endent st				
Exam achievements	Written exam				,-	$\frac{\mathrm{ded}}{\mathrm{ded}}$		
Study achievements	Successful exer				(not gra	ded)		
Forms of media	Lectures, exerc	· · · · · · · · · · · · · · · · · · ·			IZ Œ			
	- Ian Witten,	Eibe Frank,	Data Mini	ıng, Morg	gan Kauffmann	,		
Literature	2000							
 -	- Jiawei Han, Micheline Kamber, Data Mining: Concepts and							
	Techniques, M	organ Kaufi	nann, 200	0				

Module MA-INF 4113	Cognitive R	Robotics						
Workload	Credit points	Duration	Frague	nov				
180 h	6 CP	1 semester	Frequency er every year					
Module	Prof. Dr. Sver		CVCIY	Car				
coordinator	Tion. Dr. Sver	i Bellike						
Lecturer(s)	Prof. Dr. Sven Behnke							
Lecturer (s)	Programme	1 Belline	Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optiona					
Technical skills	-		_		es of the intellig	gent		
	systems track.			·	`	50-10		
	_ ~			_	perception, and	d		
	action-plannin				r r ,			
	_	•			can be taken			
		This module complements MA-INF 4114 and can be taken before or after that module.						
Soft skills		Communicative skills (oral and written presentation of solutions,						
SOIT SKIIIS		discussions in small teams), self competences (ability to accept						
	and formulate criticism, ability to analyze problems)							
Contents		Probabilistic approaches to state estimation (Bayes Filters,						
				`	s, sensor mode	ls,		
	self-localization	,	, ,		*	,		
	mapping and l	,		- '				
			` ' '		ecognition, obje	ect		
	recognition.							
Prerequisites	Required:							
	MA-INF 4101	- Theory of	Sensorime	otor Syste	ems has not bee	en		
	passed.							
	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	\mid 30 T $/$ 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	oendent st	tudy			
Exam achievements	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise particij	oation		(not gra			
Forms of media								
	• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics.							
	MIT Press, 2005.							
Titonotuno	• B. Siciliano, O. Khatib (Eds.): Springer Handbook of							
Literature	Robotics, 2008	3.						
		_	ision: Alg	orithms a	nd Application	ıs,		
	Springer 2010.							

Module	Robot Lear	ning						
MA-INF 4114	a 111	ъ	T					
Workload	Credit points	Duration	Freque	-				
180 h	6 CP	1 semester every year						
Module	Prof. Dr. Sver	n Behnke						
coordinator								
Lecturer(s)	Prof. Dr. Sver	n Behnke, Di						
Classification	Programme	~ .	Mode	Semest				
	M. Sc. Compu		Optiona					
Technical skills				-	es of the intellig	_		
					hat can learn t			
					scinating chall			
		_		_	ingredients for			
	_	eneral robot learning approach to get closer towards human-like						
	-	erformance in robotics, such as reinforcement learning, learning						
		nodels for control, learning motor primitives, learning from emonstrations and imitation learning, and interactive learning.						
	demonstration	s and imitat	ion learni	ng, and in	iteractive learn	ing.		
	This module c	This module complements MA-INF 4113 and can be taken						
	before or after	before or after that module.						
Soft skills	Communicativ	e skills (oral	and write	ten presen	ntation of solut	ions,		
		`		-	(ability to acce	,		
	and formulate	,		_	•	•		
Contents					esses, dynamic	;		
	programming,	Monte Carlo	methods	s, tempora	al-difference			
					atic regulation	,		
	differential dy	namic progra	mming, p	artially o	bservable MDI	P_{S}		
	policy gradien							
	imitation learn	ning, learning	g kinemat	ic models	, perceiving an	d		
	handling of ob	jects.						
Prerequisites	none							
	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching:	S — inder	ı nendent st	,	ı		
Exam achievements	Written exam	ce deaching,	o — maer	Zendeni st		ded)		
Study achievements	Successful exe	rcise particir	ation		(not gra			
Forms of media	Successiui exe.	rome parmer			(1100 gra	acaj		
TOTHIS OF HIEUIA	• R Sutton ar	nd A Bartor	Reinforce	ment Les	rning MIT-Pr	.bee		
	• R. Sutton and A. Barto: Reinforcement Learning, MIT-Press,							
Literature	1998.							
	• O. Sigaud and J. Peters (Eds.): From Motor Learning to							
	Interaction Learning in Robots. Springer, 2010.							

Module MA-INF 4201	Artificial Li	fe					
	G 111	D					
Workload	Credit points 6 CP	Duration	Freque	=			
180 h		6 CP 1 semester every year Prof. Dr. Sven Behnke					
Module	Prof. Dr. Svei	ı Bennke					
coordinator	D C D C	D 1 1 D	Nº1 C	1			
Lecturer(s)	Prof. Dr. Sver	n Bennke, Dr.					
Classification	Programme	-+ C-:	Mode	Semest	ter		
m 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	M. Sc. Compu		Optional		4	1	
Technical skills	Detailed under	_		_			
			_		derstanding of	tne	
C C 1 111	current state o					.1.4.	
Soft skills		•			rtificial life, and the exercises		
					on of the result		
	the homework	-	. Critical	discussic	on or the result	S OI	
Ctt-	Foundations o		collular	automate	Conway'a "C	Tama	
Contents					ent; foundation		
	nonlinear dyna			-	,	S OI	
		•	,		reinforcement		
	learning, artifi	_		,			
	self-organising		-	_			
	intelligence, pa		_	-	, and swarm		
Prerequisites	none	article Swarin	оринида				
Trerequisites	Teaching forms	at Gre	oup size	h/week	Workload[h]	CP	
Format	Lecture		oup size	2	30 T / 45 S	2.5	
1 of may	Exercises			2	30 T / 75 S	3.5	
			l coloni '		,	0.0	
T2 1:	T = face-to-fa Written exam	ce teaching; s	$\mathbf{s} = \text{maep}$	endent st		المماء	
Exam achievements					,-	$\frac{\text{ded}}{1-1}$	
Study achievements	Successful exe			:	(not gra		
Forms of media					ont of athe exe	ercise	
	group, implem simulation too		nan prog	rams, use	e of simple		
	• Christoph A		uation to	Artificial	Life The		
	Electronic Library of Science, TELOS, Springer-Verlag						
	• Eric Bonabeau, Marco Dorigo, Guy Theraulaz: Swarm						
	Intelligence: From Natural to Artificial Systems, Oxford						
Literature	University Press, Santa Fe Institute Studies in the Science of						
	Complexity.	eegles. Evoluti	onery Al	gorithma	for Single and		
			-	_	for Single and		
					Fuzzyness and		
	_	ig, r nysica-v	eriag, A	obruiger-	Verlag Compar	ıy,	
	Heidelberg						

Module MA-INF 4203	Autonomou	s Mobile S	Systems					
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semester	every y	ear				
Module	Prof. Dr. Sver	n Behnke						
coordinator								
Lecturer(s)	Dr. Dirk Schu	lz, Prof. Dr.	Sven Bel	nke				
CI 10 II	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	ter Science	Optiona	$1 \mid 2$.				
Technical skills	Profound know	vledge of dev	elopment	and test	regarding struc	cture		
	and function o	of learning, a	utonomou	s, mobile	systems;			
	Knowledge of	the computa	tional, ma	athematic	al, and technic	al		
	requirements f	or the design	n of auton	omous sy	stems for speci	fic		
	applications ar	nd for specif	c function	al enviro	nments			
Soft skills	The students v	-						
		tonomous mobile systems. They will be capable to identify						
		hat part of the applications might be improved by using state						
		f the art developments. The student will learn how to plan and						
	_	implement a software project in small working groups.						
Contents	_	-			nomous mobile			
	systems, e.g. f	_						
	SLAM-method	-	_	_				
	methods for ac	_	_	arison of a	different learnii	ng		
	paradigms for		ications.					
Prerequisites	Recommended							
	all of the follow	wing:						
	MA-INF 4101	- Theory of	Sensorim	otor Syste	ems			
	MA-INF 4113	- Cognitive	Robotics					
	Teaching forma	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	endent st	udy			
Exam achievements	Oral exam	<u> </u>				ded)		
Study achievements	Successful exer	rcise particip	ation		(not gra			
Forms of media		1			, 5			
	• J. Buchli: Mobile Robots: Moving Intelligence, Published by							
	Advanced Robotic Systems and Pro Literatur Verlag							
T:tonotune	• Sebastian Tl	hrun, Wolfra	m Burgar	d, Dieter	Fox: Probabili	stic		
Literature	Robotics, MIT	Press, 2005						
	• Howie Chose	et et al.: Pri	nciples of	Robot Mo	otion, MIT-Pre	ess,		
	2005							

Module	Technical N	leural Net	5					
MA-INF 4204								
Workload	Credit points	Duration	Freque	-				
180 h	6 CP	1 semester	0.0	ear				
Module	Prof. Dr. Joac	chim K. Anla	uf					
coordinator								
Lecturer(s)	Prof. Dr. Joac	chim K. Anla		ils Goerk	e			
Classification	Programme		Mode	Semest	ter			
	M. Sc. Compu		Optiona	I				
Technical skills	Detailed know							
		_	_		elds of applicat			
		Knowledge and understanding of technical neural networks as						
		_			nilar to concep	ts of		
	brain function							
Soft skills					al paradigms f			
		eural networks that are capable to solve a given task. They can						
	_	iscuss the pro and cons with respect to efficiency and risk. The						
	_	will be capable to plan and implement a small project with state						
		of the art neural network solutions.						
Contents					nets, Hopfield r	iets,		
	self organizing	- \		_				
	learning vector	_						
					ning, Q-learning	g,		
	support vector		_	_				
		-			on approximat	,		
	-				speech process	ing,		
	action plannin			_				
	_				re and software	e:		
	tools, simulate	ors, analog a	nd digital	neural ha	rdware.			
Prerequisites	none				I			
	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	endent st	udy			
Exam achievements	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded		
Forms of media								
	• Christopher	-						
	Recognition, Oxford University Press, ISBN-10: 0198538642,							
Literature	ISBN-13: 978-							
	• Ian T. Nabney: NETLAB. Algoriths for Pattern Recognition,							
	Springer, ISBN	N-10: 185233	4401, ISB	N-13: 978	8-1852334406			

Module MA-INF 4207	Dynamically Reconfigurable Systems						
Workload	Credit points	Duration	Frequ	ency			
180 h	6 CP	1 semest	_	st every 2	years		
Module	Prof. Dr. Joachim K. Anlauf						
coordinator							
Lecturer(s)	Prof. Dr. Joac	chim K. Aı	nlauf				
CI :C ::	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Scienc	e Option	al 2.			
Technical skills	Knowledge of	Knowledge of the most important FPGA architectures, ability					
	to select appro	to select appropriate FPGAs for a given application, overview of					
	programming	programming tools					
Soft skills	Communicativ	Communicative skills (oral and written presentation of					
	solutions), soc	ial skills (a	ability to s	olve proble	ems in small tea	ams,	
	discussions of	solution co	oncepts) se	lf compete	nces (ability to)	
	accept and for	mulate cri	ticism, abi	lity to ana	lyze problems)		
Contents	Architecture o	f FPGAs,	Configura	ole Logic E	Blocks, Wiring		
	Ressources, Sp	pecial Bloc	ks, Hardw	are Descrip	tion Language	s,	
	Synthesis, Tec	hnology M	apping, P	ace and Re	oute, FPGA		
	Computing, P	artial Reco	nfigurabil	ity			
Prerequisites	none						
	Teaching forms	at	Group size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	g; S = ind	ependent s	tudy		
Exam achievements	Oral exam				(gra	ided)	
Study achievements	Successful exe	rcise partic	eipation		(not gra	ided)	
Forms of media							
Literature	Current resear	ch papers	and techn	ical docum	entation		

Module	Seminar Vi	sion Syste	ms					
MA-INF 4208	G 114 1 4	D						
Workload	Credit points 4 CP	Duration 1 semester	Frequency					
120 h	4 CP 1 semester every semester Prof. Dr. Sven Behnke							
Module	Prof. Dr. Svei	і Беппке						
coordinator	Doof Do Care	Dobreleo De	of Dn Io	a alaissa IV	Aralouf			
Lecturer(s)		Prof. Dr. Sven Behnke, Prof. Dr. Joachim K. Anlauf, Dr. Nils Goerke						
Classification	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.			
Technical skills	• Knowledge i	n advanced t	opics in the	ne area o	f technical vision	on		
	systems, such	as image seg	mentation	, feature	extraction, and	d		
	object recogni	tion.						
	• Ability to ur			-				
				ent them	in a research t	alk		
		s well as in a seminar report.						
Soft skills	_	belf-competences (time management, literature search,						
		self-study), communication skills (preparation and clear didactic						
	_		,		sion, structured			
	writing of sem	inar report),	social ski	lls (abilit	y to formulate	and		
	accept criticisi							
Contents					l journals in th	e		
	field of vision	systems cove	ring funda	mental t	echniques and			
	applications.							
Prerequisites	Recommended							
	At least 1 of the	_						
	MA-INF 4111		Learning	and Ana	lysis Systems:			
	Machine Learn	ning						
	MA-INF 4204	- Technical	Neural Ne	ts				
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
rormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa			endent st				
Exam achievements	Oral presentat	ion, written	report		· -	ided)		
Study achievements					(not gra	ided)		
Forms of media	200	~						
	• R. Szeliski: Computer Vision: Algorithms and Applications,							
	Springer 2010.							
Literature	• C. M. Bishop: Pattern Recognition and Machine Learning,							
	Springer 2006.		~	,				
				uter Visi	ion: A Modern			
	Approach, Prentice Hall, 2003.							

Module MA-INF 4209	Seminar Principles of Data Mining and Learning Algorithms						
Workload	Credit points	Duration	Freque	ncv			
120 h	4 CP	1 semeste	_	-			
Module	Prof. Dr. Stef		or cvery y				
coordinator	1101. D1. 5001	air Wiober					
Lecturer(s)	Prof. Dr. Stefan Wrobel						
	Programme	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona				
Technical skills	•		-		zed topics in th	ie	
	area of machin	-	0	•	*		
		competence to independently study scientific literature, present					
	_	t to others and discuss it with a knowledgeable scientific					
	auditorium. L	auditorium. Learn how to scientifically present prior work by					
	others, in writing and in presentations.						
Soft skills	Communicativ	Communicative skills (preparing and presenting talks, written					
	presentation o	f contents i	n a longer	document), self compete	nces	
	(time manager	ment with l	ong-rangin	g deadline	es, ability to ac	cept	
	and formulate	criticism, a	bility to an	nalyse, cre	eativity).		
Contents	Theoretical, st	atistical an	d algorithm	nical prin	ciples of data		
	mining and lea	arning algor	ithms. Sea	rch and c	ptimization		
	algorithms. Sp	pecialized le	arning algo	orithms fr	om the frontier	of	
	research. Fund	damental re	sults from	neighbou	ring areas.		
Prerequisites	Recommended						
	At least 1 of t	he following	: :				
	MA-INF 4111	- Intelliger	t Learning	and Ana	lysis Systems:		
	Machine Learn	ning					
	MA-INF 4112	– Intelliger	t Learning	and Ana	lysis Systems:		
	Data Mining a	and Knowle	dge Discov	ery			
Б	Teaching forms	at (Group size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching	S = inder	endent st	udv		
Exam achievements	Oral presentat					ded)	
Study achievements	_	,			(not gra		
Forms of media	Scientific pape	ers and web	sites, intera	active pre			
	* *				ards the end of	f the	
Literature	previous seme						

Module MA-INF 4210	Seminar Ad	lvanced	Topi	ics in '	Technica	al Informati	cs
Workload	Credit points	Duration		Engguer	2011		
120 h	4 CP	1 semes					
Module	Prof. Dr. Joachim K. Anlauf						
coordinator	1 101. D1. 30ac	1101. Dr. Joachini IX. Alliaur					
	Duef Du Jees						
Lecturer(s)		Prof. Dr. Joachim K. Anlauf Programme Mode Semester					
Classification	Programme	, a .					
	M. Sc. Compu			_		3.	
Technical skills	_	Current Topics in Technical Informatics					
Soft skills		Communicative skills (preparing and presenting talks, preparing					
	a structured w	a structured written document), social skills (ability to accept					
	and formulate	criticism,	discu	ussions	of current	content) self	
	competences (time mana	agem	ent with	n long-ran	nging deadlines	3,
	understanding	of research	ch top	pics from	n original	literature)	
Contents	Current topics	s such as:	new a	architec	tures of c	omputers or	
	FPGAs (field	programm	able	gate ar	rays) or n	ew application	s of
	dynamically re	econfigura	ble sy	ystems	,		
Prerequisites	none			<u> </u>			
	Teaching form	at	Grou	ıp size	h/week	Workload[h]	CP
Format	Seminar		-	10	2	30 T / 90 S	4
	T = face-to-fa	ce teachin	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en re	port		(gra	ded)
Study achievements						(not gra	ded)
Forms of media						-	
Literature	Current resear	ch papers					

Module	Seminar Co	Seminar Cognitive Robotics					
MA-INF 4211							
Workload	Credit points	Duration	Frequency				
120 h	4 CP	1 semester	er every semester				
Module	Prof. Dr. Sver	ı Behnke					
coordinator							
Lecturer(s)	Prof. Dr. Sver	Prof. Dr. Sven Behnke, Dr. Nils Goerke					
Classification	Programme Mode			Semes	ter		
Classification	M. Sc. Compu	ter Science	Optional	2. or 3	3.		
Technical skills	Knowledge in	advanced to	pics in the	area of o	cognitive robot:	ics,	
	such as robot	perception, a	action plan	ning, and	d robot learnin	g.	
	Ability to und	erstand new	research i	esults pro	esented in origi	inal	
	_	scientific papers and to present them in a research talk as well as					
	in a seminar re	_					
Soft skills		Self-competences (time management, literature search,					
	_	elf-study), communication skills (preparation and clear didactic					
	presentation of		·-	_			
	writing of sem		*		*		
	accept criticism						
Contents	Current resear	<u> </u>				e	
	field of cogniti				-		
	applications.		O .		•		
Prerequisites	Recommended	:					
	At least 1 of the	he following:					
	MA-INF 4113	 Cognitive 	Robotics				
	MA-INF 4114	Ü					
	Teaching forma		oup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching:	S = indep	endent st	,	ı	
Exam achievements	Oral presentat					ded)	
Study achievements	1	, , , , , , , , , , , , , , , , , , , ,	<u> </u>		(not gra		
Forms of media					· · ·		
	• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics.						
i e e e e e e e e e e e e e e e e e e e	MIT Press, 2005.						
	MIT Press, 20	U3.					
Literature	,		Eds.): Spr	inger Ha	ndbook of		
Literature	MIT Press, 20 • B. Siciliano, Robotics, 2008	O. Khatib (Eds.): Spr	inger Ha	ndbook of		

Module	Humanoid Robotics							
MA-INF 4215								
Workload	Credit points	Duration	Freque	ісу				
180 h	6 CP	1 semester	at least	every 2	years			
Module	Prof. Dr. Mar	en Bennewit	Z					
coordinator								
Lecturer(s)	Prof. Dr. Mar	Prof. Dr. Maren Bennewitz						
Classification	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optional	l 2-4.				
Technical skills	This lecture co	This lecture covers techniques for humanoid robots such as						
	perception, na	perception, navigation, and motion planning.						
Soft skills	Communicativ	Communicative skills (oral and written presentation of solutions,						
	discussions in	discussions in small teams), ability to analyze problems.						
Contents	Self-calibration	elf-calibration with least squares, 3D environment						
	representation	epresentations, self-localization with particle filters, footstep						
	planning, inve	rse kinemati	cs, whole-l	oody mot	ion planning w	γ ith		
	rapidly explori	ing random	rees, stati	stical tes	ting.			
Prerequisites	Recommended	:						
	MA-INF 4113	- Cognitive	Robotics					
	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	endent st	udy			
Exam achievements	Oral exam				(gra	ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
	• S. Thrun, W	. Burgard a	nd D. Fox	: Probabi	listic Robotics			
	MIT Press, 2005.							
T*4	• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics							
Literature	• K. Harada, l	E. Yoshida, Ì	K. Yokoi (Eds.), Mo	otion Planning	for		
	Humanoid Ro	bots, Springe	er	*				
	• Selected rese	earch papers						

Module MA-INF 4216	Data Minin Bioinformat		chine Le	arning]	Methods in		
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP						
Module	Dr. Holger Frö	öhlich					
coordinator							
Lecturer(s)	Dr. Holger Fröhlich						
Classification	Programme M. Sa. Compu	tor Sajonao	Mode Optiona	Semest	ter		
Technical skills		M. Sc. Computer Science Optional 3 understanding and knowledge of fundamental data mining and					
recimieat skins	machine learni	_	_		n dava mining	ana	
	- understandin	_		in bioinfo	rmatics		
Soft skills	- communication					to	
Soft Skills	exercises	on. orar an	a willoudi p		on or solutions		
	- self-competer	nces: ability	, to analyz	e annlicat	ion problems a	nd	
				с аррпсас	ion problems a	iia	
	to formulate possible solutions - practical skills: ability to practically implement solutions						
	_	· ·	-	-			
Contents		- social skills: working in a small team with other students This lecture gives a broad overview about frequently used					
Contents					- 0		
	statistical techniques as well as data mining and machine learning algorithms. The use of the respective methods to solve						
	problems in bioinformatics is explained. The goal is to						
	understand the explained methods, being able to apply them						
	correctly and p	-	_				
	following topic		ed in the co	ontext of	their application	on in	
	bioinformatics:	:					
	- Short introdu	action to B	oinformati	cs and Bi	omedicine		
	- Statistical Ba				•		
	inference, stati				models, logisti	ic	
	regression, Pri	ncipal Com	ponent An	alysis			
	- Clustering						
	- Hidden Mark	ov Models					
	- Principles of	Supervised	Machine I	Learning			
	- Elastic Net						
	- Basics of deep learning						
Prerequisites	none	<u> </u>					
	Teaching forma	at (Group size	h/week	Workload[h]	СР	
Format	Lecture		-	2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-face	ce teaching	S = indep	endent st	udy		
Exam achievements	Written exam				(gra	ded)	
Study achievements	Successful exer	rcise partic	pation		(not gra	$\overline{\mathrm{ded}}$	
Forms of media							
	T. Hastie, R. 7	,		n, The El	ements of		
	Statistical Learning, Springer, 2008						
Literature	S.Boslaugh, P. Watters, Statistics in a Nutshell, O'Reilly, 2008						
	N. Jones, P. P. Algorithms, M			on to Bioi	informatics		

Nf - J1-	Sominar Me	ohino I	oonni	ing Ma	ethoda	in the Life	
Module MA-INF 4217	Seminar Ma Sciences	icilile L	earm	ing ivie	einous	in the Life	
Workload	Credit points	Duration	T	Frequen	CV.		
120 h	4 CP	1 semest		every ye			
Module	Dr. Holger Frö			overy je			
coordinator		,1111011					
Lecturer(s)	Dr. Holger Fröhlich						
	Programme		M	ode	Semest	ter	
Classification	M. Sc. Compu	ter Scienc	e O	ptional	4.		
Technical skills	- understandin	g and kno	wledg	ge of ma	chine lea	arning methods	
	and their appl	ication in	mode	rn life s	ciences, e	e.g. biomedicine	
Soft skills	- communicati	- communication: oral scientific presentation of a defined topic					
	- self-competer	nces: abilit	ty to i	identify	relevant	literature for a	
	given topic; ab	given topic; ability to read, understand and analyze scientific					
	publications - social skills: ability to discuss a scientific topic with other students and the staff						
Contents	Machine learning techniques play a crucial role in modern life						
	sciences, including biomedicine. The goal of this seminar is to						
	discuss a varie	ty of mach	nine le	arning	techniqu	es in the context of	
	their application	on to solve	e real-	world p	roblems	in biomedicine.	
	Topics will be	selected fr	rom th	ne follov	ving area	as:	
	- Ensemble lea	rning					
	- Survival and	disease pr	rogress	sion mo	dels		
	- Bayesian Net	works					
	- Stochastic pr Mixture Mode		.g. Ga	ussian	Proceses	, Dirichlet Process	
	- MCMC meth	ods					
	- Deep learning	g methods	s. e.g.	DNNs.	CNNs. I	Deep Belief	
	Networks	5 11100110 010	,	211110,	011110, 1	S cop Boner	
	- feature select	ion and n	on-lin	ear emb	edding r	methods	
	- multi-modal	data fusio	n tech	niques			
	Attendees will	be asked	to per	form re	search a	bout their topic in	
	a self-responsib		_			1	
Prerequisites	Recommended	•					
	MA-INF 4216	– Data M	ining	and Ma	chine Le	earning Methods in	
	Bioinformatics						
Format	Teaching forms	at	Group		h/week	Workload[h] CP	
	Seminar		10	0	2	30 T / 90 S 4	
	T = face-to-face	ce teaching	g; S =	= indepe	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en rep	ort		(graded)	
Study achievements						(not graded)	
Forms of media	powerpoint	, ,					
Literature	selected journa	al and con	terenc	e paper	S		

Module MA-INF 4226	Lab Paralle	l Computi	ng for I	Mobile 1	Robotics			
Workload	Credit points	Duration	Freque	nev				
270 h	9 CP	1 semester	_	at least every 2 years				
Module	Prof. Dr. Mar							
coordinator	1 101. D1. Mai	en Bennewie	Z					
Lecturer(s)	Prof Dr Mar	Prof. Dr. Maren Bennewitz						
Lecturer (s)	Programme	en Bennewie	Mode	Seme	stor			
Classification	M. Sc. Compu	iter Science	Optiona		3001			
Technical skills	-		•		the design and			
Technical skins	implementatio	•	•		O			
	_	-	_	10111115 111	the context of			
Soft skills	_	notion planning and navigation. Ability to properly present and defend design decisions, to						
SOIT SKIIIS		orepare readable documentation of software; skills in						
	_ ^ ^	constructively collaborating with others in small teams over a						
			_		own results into the			
	state-of-the-ar	,		ones	OWII TESUIUS IIIUO UIIC			
Contents	Parallel progra			CHDA	hortest nath			
Contents	planning, colli	0	,	,	•			
Prerequisites	Recommended		5, VISIDIII	y grapii,	n algorithm			
Trerequisites	C++, Linux.	•						
	ĺ	. 1	1	41 1				
			arouna p	atn piani	ning, one of those			
	courses might	-						
	MA-INF 4203	: Autonomou	ıs Mobile	Systems				
	MA-INF 4113	: Cognitive I	Robotics					
	MA-INF 4310	: Lab Mobile	Robots					
Б	Teaching forms	at Gre	oup size	h/week	Workload[h] CP			
Format	Lab		8	4	60 T / 210 S 9			
	T = face-to-fa	ce teaching:	S = inder	pendent s	study			
Exam achievements	Oral presentat	<u> </u>		•	(graded)			
Study achievements	_	,			(not graded)			
Forms of media					, , ,			
Literature								

Module MA-INF 4228	Foundations	s of Data	Science				
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste	r every	year			
Module	Dr. Michael N	lüsken					
coordinator							
Lecturer(s)	Dr. Michael N	lüsken					
Classification	Programme		Mode	Seme			
Classification	M. Sc. Compu		-				
Technical skills					l spaces in geom	netry	
	_	_		ecomposi	tion. Basics in		
	machine learni	ing and clus	tering.				
	Skills: Unders	tanding of 1	nathemati	ical tools.			
Soft skills	Competences:	Application	to data	science pr	oblems and abi	lity	
	to assess similar methods.						
Contents		Data science aims at making sense of big data. To that end,					
	various tools have to be understood for helping in analyzing the						
	arising structures.						
	Often data con	mes as a co	lection of	vectors w	vith a large num	ıber	
	of components	s. To unders	stand their	r commor	n structure is th	.e	
	first main obje	ective of un	derstandin	g the dat	a. The geometr	У	
	and the linear	algebra bel	aind them	becomes	relevant and		
	enlightning. Y	et, the intu	ition from	low-dime	ensional space to	urns	
	out to be ofter	n misleading	g. We nee	d to be av	ware of the		
	particular prop	perties of hi	gh-dimens	sional spa	ces when worki	ng	
	with such data				·		
	singular vector	-		-	-		
	_	-			ng. If time perm		
				nich are tl	he second most	used	
	model for real	world phen	omena.				
Prerequisites	none				T		
	Teaching forms	at G	oup size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa		S = inde	pendent s	study		
Exam achievements	Schriftliche Pr				(gra	ded)	
Study achievements	Erfolgreiche Ü	bungsteilna	hme		(not gra	ded)	
Forms of media							
Literature	,	-	,	avindran	Kannan (2018-	⊦).	
Liverature	Foundations of Data Science.						

Module MA-INF 4229	Pattern Rec	ognition ((1)				
Workload	Credit points	Duration	Frequer	2011			
270 h	9 CP	1 semester	every ye	-			
Module	Prof. Dr. Christ			A1			
coordinator	Tion. Dr. Christ	ian Dauckna,	30				
Lecturer(s)	Prof. Dr. Christ	ian Rauckha	TO.				
Lecturer (s)	Programme		Mode	Semester			
Classification	M. Sc. Compute		Optional	2.			
Technical skills	Upon completion		_				
recimical skins	-				1 .		
	• devise mathem		s for prob	lems in dat	a analysis,		
	clustering, and c		1 _1:	↓1 f	- 1-1 C++: 1		
	• implement basic and advanced algorithms for model fitting an antimization						
	optimization • implement basic and advanced algorithms for data clustering						
	• implement bas classification	ic and advan	cea aigori	tnins for da	ata ciustering an	ıa	
		is and advan	and almoni	there for no		***	
Soft skills	• implement basic and advanced algorithms for pattern recognition. Students will learn about the mathematical and algorithmic						
SOIL SKIIIS	foundations of m				9	1	
	learn about basic				•		
Contents	to implement them on their own, and how to put them into pract						
Contents	• fundamental concepts, prerequisites, and procedures in pattern recognition						
	• basic and adva	nced concen	s in linea	r algebra			
	basic and adva basic and adva	_		-	rv and statistics		
	• least squares to	_	-		ry arra sociosios		
	• maximum likel	-		V			
	• maximum a-po		-				
	Bayesian inference						
	• fundamental as			ry and the	VC dimension		
	• the curse of dir	-	0	V			
	• methods and a		data clus	stering			
	• Gaussian mixt						
	• the method of	Lagrange mi	ıltipliers a	and the KK	T conditions		
	• quadratic and	linear discrir	ninant ana	alysis			
	• algorithms for	constrained	optimizati	on			
	• support vector	machines					
	• the kernel trick	ζ.					
	• neural network						
	• Hebbian learni	9					
Prerequisites	Recommended:						
	Students should					oility	
	theory, and stati						
	Teaching forma	t G	roup size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-face	teaching; S	= indepen	dent study			
Exam achievements	Schriftliche Prüf				(gra	aded)	
Study achievements	Erfolgreiche Übu				(not gra	aded)	
Forms of media	• lecture slides a	re made avai	lable onli	ne			
	• lecture notes w					line	
	Bishop, "Pattern	Recognition	and Mac	hine Learni	ng"		
Literature	Duda, Stork, Ha	rt, "Pattern	Classificat	ion"			
	MacKay, "Inform				rning Algorithm	e"	
	macixay, iiiiofii	iation Theor	y, imereno	e, and Lea	iming Angorithini	o	

Module MA-INF 4230	Advanced Methods	s of Inform	ation Re	etrieval				
Workload	Credit points Duration	n Freque	ncy					
180 h	6 CP 1 semes	1 -	-					
Module	Prof. Dr. Elena Demid							
coordinator								
Lecturer(s)	Prof. Dr. Elena Demide	ova						
Classification	Programme	Mode	Semest	ter				
Classification	M. Sc. Computer Scien							
Technical skills	This module introduces data structures, and alg structured and semi-str knowledge graphs, relat	gorithms of in actured data	nformation (includin	n retrieval for g, for example				
Soft akilla	choosing appropriate da specific applications and machine learning-based	At the end of the module, the students will be capable of choosing appropriate data structures and retrieval algorithms for specific applications and correctly apply relevant statistical and machine learning-based information retrieval procedures.						
Soft skills	discussion of solutions.	Communication skills: oral and written presentation and discussion of solutions.						
Contents	Self-competences: abilit The module topics included							
	and efficient algorithms that enable end-users to effectively obtain the most relevant search results from structured, heterogeneous, and distributed data sources. Furthermore, we will study the corresponding evaluation techniques as well as novel applications.							
Prerequisites	none							
	Teaching format	Group size	h/week	Workload[h]	CP			
Format	Lecture		2	30 T / 45 S	2.5			
	Exercises		2	30 T / 75 S	3.5			
	T = face-to-face teaching	ng; S = indep	endent st					
Exam achievements	Schriftliche Prüfung				ded)			
Study achievements	Erfolgreiche Übungsteil	nahme		(not gra	ded)			
Forms of media								
	 Christopher D. Mann Schütze, Introduction to University Press. 2008. Bhaskar Mitra and N Neural Information Ret 	Selected chapters from: • Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. • Bhaskar Mitra and Nick Craswell (2018), "An Introduction to Neural Information Retrieval", Foundations and Trendső in						
Literature	 Ridho Reinanda, Edga "Knowledge Graphs: An Foundations and Trend 4, pp 289-444. Jeffrey Xu Yu, Lu Qir Databases. Synthesis L. Claypool Publishers. 20 	Information Retrieval: Vol. 13: No. 1, pp 1-126 Ridho Reinanda, Edgar Meij and Maarten de Rijke (2020), "Knowledge Graphs: An Information Retrieval Perspective", Foundations and Trendső in Information Retrieval: Vol. 14: N						
	Further references to rethe lecture.	elevant materi	al will be	provided duri	ng ——			

Module MA-INF 4231	Seminar Ad	lvanced To	pics in I	Informa	tion Retriev	al			
Workload	Credit points	Duration	Frequen	ncy					
120 h	4 CP								
Module	Prof. Dr. Elena Demidova								
coordinator									
Lecturer(s)	Prof. Dr. Elena Demidova								
CI :C ::	Programme	Programme Mode Semester							
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.				
Technical skills	This module of	concentrates	on speciali	zed topic	s in information	n			
0.6.1.11	study of state- discussion wit audience.								
Soft skills	Communication skills: oral and written presentation of scientific content. Self-competences: the ability to analyze problems, time management, creativity.								
Contents	Statistical and machine learning-based information retrieval methods, including typical steps of the information retrieval process: data collection, feature extraction, indexing, retrieval, ranking, and evaluation. Specialized data representation and retrieval methods for selected data types and applications in specific domains.								
Prerequisites	Recommended MA-INF 4230		Methods o	of Informa	ation Retrieval				
TD 4	Teaching form	at G	oup size	h/week	Workload[h]	CP			
Format	Seminar		10	2	30 T / 90 S	4			
	T = face-to-face teaching; S = independent study								
Exam achievements	Oral presentat					ded)			
Study achievements	None	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	100010		(not gra				
Forms of media	110110				(1100 8100	-aca)			
Torms or media	Selected chapt	ers from:							
Literature	 Christopher Schütze, Intro University Pre Bhaskar Mit Neural Inform Information R 	D. Manning duction to In ess. 2008. cra and Nick ation Retrievativetrieval: Vol	formation Craswell (val ", Foun 13: No.	Retrieva (2018), "Adations a 1, pp 1-1:	An Introduction and Trendső in 26.	n to			
	Further relevant literature will be announced at the beginning of the seminar.								

Module	Lab Inform	ation Retr	ieval in	Practio	ce				
MA-INF 4232									
Workload	Credit points								
270 h	9 CP	9 CP 1 semester every year							
Module	Prof. Dr. Elena Demidova								
coordinator									
Lecturer(s)	Prof. Dr. Elena Demidova								
Classification	Programme		Mode	Seme	ster				
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 2. or 3.							
Technical skills	This module of	This module concentrates on practical experience in information							
	retrieval. Participants acquire basic knowledge and practical experience in designing and implementing information retrieval								
	systems for sp								
Soft skills	Communication skills: the ability to work in teams.								
	Self-competences: the ability to analyse problems and find								
	practical solut	practical solutions. Time management, creativity, presentation							
	of results.								
Contents	Practical application of information retrieval methods to solve								
	retrieval problems on real-world data and evaluate proposed								
	solutions.								
Prerequisites	Recommended:								
	MA-INF 4230	- Advanced 1	Methods	of Inform	nation Retrieval	l			
	MA-INF 4231	- Seminar A	dvanced	Topics in	Information				
	Retrieval								
Format	Teaching form	at Gro	up size	h/week	Workload[h]	CP			
Format	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching:	S = inde	pendent s	study				
Exam achievements	Oral presentat			1		aded)			
Study achievements	None	,	•		(not gra				
Forms of media					(0				
	Selected chapt	ers from:							
	_		Prabha	kar Ragh	avan and Hinrid	-h			
	• Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge								
	Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008.								
Literature	=		Craswell	(2018). "	An Introduction	n to			
Ditoratare				, , ,	and Trendső in				
	Information R								
				,		ing			
		nces to releva	ш шасе.	riai WIII D	e provided duri	шg			
	the lab.								

Module	Advanced L	earning S	systems						
MA-INF 4302		J							
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP	1 semeste	r every 2	2 years					
Module	Prof. Dr. Stefan Wrobel								
coordinator									
Lecturer(s)	Prof. Dr. Stefan Wrobel								
Classification	Programme		Mode	Semes	ter				
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 2. or 3.							
Technical skills	Participants sp		•	•	O	ıe			
	particular class of learning algorithms, they acquire the necessary knowledge to improve existing algorithms and								
		construct their own within the given class, all the way up							
~	research fronti		_		. 1 1				
Soft skills	In group work	•	-						
	communication								
	planning, and					ers.			
Contents	The module ea		icentrates	on one or	more specific				
	algorithm class	, 0							
	• kernel machi								
	• neural netwo				1				
	• probabilistic			ng approa	ches				
	• logic-based learning approaches								
T	• reinforcemen								
Prerequisites	Recommended all of the follow								
	MA-INF 4111 Machine Learn	_	t Learning	and Ana	lysis Systems:				
	MA-INF 4112	0	t Learning	and Ana	lycic Systems				
	Data Mining a	_	_		iysis bystems.				
	Teaching forms		roup size	h/week	Workload[h]	СР			
Format	Lecture	10	Toup Size	· '	30 T / 45 S	2.5			
Torrido	Exercises			$\frac{2}{2}$	30 T / 75 S	3.5			
	T = face-to-fa	ao tonahina	S — indo	l oondont st	,				
Exam achievements	Written exam	ce teaching	5 – maer	Jendent st		ided)			
Study achievements	Successful exer	rcisa partici	nation		(not gra				
Forms of media	lectures, exerc				(Hot gra	ided)			
Torms or media				ng with K	ernels The M	ſТ			
	• B. Schoelkopf, A.J. Smola, Learning with Kernels, The MIT Press, 2002, Cambridge, MA								
	• John Shawe-Taylor, Nello Christianini, Kernel Methods for								
	Pattern Analysis, CUP, 2004								
	• Christopher	, ,		gnition ar	nd Machine				
Literature	Learning, The			_					
		_			nce, and Learni	ing			
	Algorithms, 20			- /	•	J			
	• Richard Duc		art, David	Stork, Pa	ttern				
	Classification,		• ~						

Module MA-INF 4303	Learning fro	om Non-S	tandard	Data				
Workload	Credit points	Duration	Freque	nev				
180 h	6 CP	1 semester	_	-				
Module	Prof. Dr. Stefan Wrobel							
coordinator								
Lecturer(s)	Prof. Dr. Stefa	Prof. Dr. Stefan Wrobel, Dr. Tamas Horvath						
Cl. 'C '	Programme	Programme Mode Semester						
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 2. or 3.						
Technical skills	Participants de	Participants deepen their knowledge of learning systems with						
	respect to one particular non-standard data type, i.e.,							
	non-tabular data, as they are becoming increasingly important							
		in many applications. Each type of data not only requires specialized algorithms but also knowledge of the surrounding pre- and postprocessing operations which is acquired by the participants in the module. In group work, students acquire the necessary social and communication skills for effective team						
		work and project planning, and learn how to present software projects to others.						
Soft skills		Communicative skills (oral and written presentation of solutions,						
		discussions in teams), self-competences (ability to accept and						
	formulate criti	cism, ability	to analys	e, creativ	ity in the cont	ext		
	of an "open en	of an "open end" task)						
Contents	The module w		,		_			
	particular non-				_	ct		
	Mining, Multin			_	Learning from			
	structured dat		ata Minin	g				
Prerequisites	Recommended all of the follow							
			т .	1 /	1 . 0 .			
	MA-INF 4111 Machine Learn	_	Learning	and Ana	lysis Systems:			
			T:	1	l:- C+			
	MA-INF 4112 Data Mining a	_	_		iysis Systems:			
	Teaching forms		roup size	h/week	Workload[h]	СР		
Format	Lecture	it G	Toup Size	2	30 T / 45 S	2.5		
2 32 22 22	Exercises			$\frac{2}{2}$	30 T / 75 S	3.5		
	T = face-to-face	ce teaching:	S = inder	I	,	1		
Exam achievements	Written exam	ce teaching,		Jendent Bt		ided)		
Study achievements	Successful exer	cise particip	ation		(not gra			
Forms of media	lectures, exerci				· 0			
	• Gennady An	drienko, Na	talia Andı	rienko, Ex	ploratory Ana	lysis		
	of Spatial and	Temporal Γ	ata, Sprir	nger, 2006				
	• Diane J. Coo		B. Holde	er, Mining	Graph Data,			
	Wiley & Sons,				·			
Literature		ıı, Nada Lav	rac, Relat	nonal Dat	a Mining,			
	• Saso Dzeroski, Nada Lavrac, Relational Data Mining, Springer, 2001							
	• Sholom M. Weiss, Nitin Indurkhya, Tong Zhang, Fred J.							
			_					

Module MA-INF 4304	Lab Cognit	ive Roboti	cs						
Workload	Credit points	Duration	Frague	nev					
270 h	9 CP	1 semester	Frequency every semester						
Module	Prof. Dr. Sven Behnke								
coordinator	Tion. Dr. Svei	1101. D1. Sven bennke							
Lecturer(s)	Prof Dr Svoi	Prof. Dr. Sven Behnke							
Lecturer(s)	Programme	i Dellike	Mode	Somo	zton.				
Classification	_	Programme Mode Semester M. Sc. Computer Science Optional 2. or 3.							
Technical skills	-								
Technical skills	_	Participants acquire practical experience and in-depth knowledge in the design and implementation of perception and							
	control algorithms for complex robotic systems. In a small group, they analyze a problem, realize a state-of-the-art								
					e-or-the-art				
Soft skills	· ·	solution, and evaluate its performance.							
Soft Skills	Self-competences (time management, goal-oriented work, ability to analyze problems and to find practical solutions),								
			_		l teams, oral ar	d			
		`	_		*	ıa			
	written presentation of solutions, critical examination of								
Ctt-	implementations) Robot middleware (ROS), simultaneous localization and								
Contents	mapping (SLA								
	\	, ·		_		ation			
		=		_	on, person dete				
	mobile manipu	_		_	ning and contro	η,			
Dronogwiaitas	Recommended		111-10000	meracuc	·11.				
Prerequisites	At least 1 of t								
		_	D 1						
	MA-INF 4113	Ü							
	MA-INF 4114		rning						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP			
1 or may	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching;	S = inder	pendent s	study				
Exam achievements	Oral presentat					ided)			
Study achievements					(not gra				
Forms of media									
	• S. Thrun, W	7. Burgard a	nd D. Fox	: Probab	ilistic Robotics				
	MIT Press, 20	_							
Literature	B. Siciliano,		Eds.): Sp	ringer Ha	andbook of				
	Robotics, 2008		, -	=					
	• Selected research papers.								

Module	1	_		cation o	f Data Mini	ng		
MA-INF 4306	and Learnin							
Workload	Credit points	Duration	Freque	-				
270 h	9 CP	1 semester	every	year				
Module	Prof. Dr. Stef	an Wrobel						
coordinator								
Lecturer(s)		Prof. Dr. Stefan Wrobel						
Classification	Programme		Mode	Seme	ster			
	•	M. Sc. Computer Science Optional 3.						
Technical skills		Students will acquire in-depth knowledge in the construction						
	_	and development of intelligent learning systems for machine						
	_	learning and data mining. They learn how to work with existing state-of-the-art systems and apply them to application						
	state-of-the-ar							
		-	g them for	or the rec	quirements of the	ıeir		
	particular tasl	ζ.						
Soft skills	Communicativ	Communicative skills (appropriate oral presentation and written documentation of project results), social skills (ability to work in						
	documentation							
	teams), self-co	ompetences (time man	agement,	aiming at			
	long-range goa	als under lim	ited resso	ources, ab	ility to work u	nder		
	pressure, ability to accept/formulate ciriticsm)							
Contents	Data storage a	and process	nodels of	data ana	lysis. Common	1		
	open source fr	ameworks fo	r the con	struction	of data analysi	İs		
	systems, speci	alized statist	ical pack	ages. Pre	-processing too	ls.		
	Mathematical	libraries for	numerica	l comput	ation. Search a	nd		
	optimization r	methods. Use	er interfac	ces and v	isualization for			
	analysis system	ms. Data an	alysis algo	orithms for	or embedded ar	id		
	distributed sys	stems. Ubiqu	itous dis	covery sy	stems.			
Prerequisites	Recommended	l:						
	At least 1 of t	he following:						
	MA-INF 4111	– Intelligent	Learning	and Ana	alysis Systems:			
	Machine Learn	_		,				
		Ü	Learning	rand An	alysis Systems:			
	Data Mining a	0		•	arysis bystems.			
	Teaching form		oup size	h/week	Workload[h]	СР		
Format	Lab	at GI	8	4	60 T / 210 S	$\frac{GI}{9}$		
			ı	_		9		
	T = face-to-fa			pendent s				
Exam achievements	Oral presentat	tion, written	report		,-	aded)		
Study achievements					(not gra	aded)		
Forms of media	Computer Sof	· · · · · · · · · · · · · · · · · · ·		*				
Literature			l be anno	unced to	wards the end of	of the		
Literature	previous semester.							

Module	Lab Field Programmable Gate Arrays							
MA-INF 4307								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	at least every 2 years					
Module	Prof. Dr. Joac	Prof. Dr. Joachim K. Anlauf						
coordinator								
Lecturer(s)	Prof. Dr. Joachim K. Anlauf							
Classification	Programme Mode Semester							
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 2. or 3.						
Technical skills	Development a	Development and simulation of digital circuits in VHDL and						
	SystemC, expe	SystemC, experience with synthesizable subsets, knowledge of						
	the design pat	the design path from the idea to a realized circuit implemented						
	in an FPGA (field programmable gate array)							
Soft skills	Communicative skills (oral and written presentation of results),							
	`	social skills (ability to cooperate in small teams, discussions of						
	solution conce	solution concepts) self competences (ability to accept and						
	formulate criti	formulate criticism, ability to analyze and find practical						
		solutions to problems)						
Contents					, and Synthesis,			
			- '		on, and Synthesi	is,		
	Synthesizable	,	t of Impl	ementatio	ons on FPGA			
	Evaluation Bo	ards						
Prerequisites	Recommended	:						
	MA-INF 4207	- Dynamica	lly Recon	figurable	Systems			
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	\mathbf{CP}		
Tormat	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching;	S = inde	pendent s	study			
Exam achievements	Oral presentat	ion, written	report		(grac	led)		
Study achievements					(not grad	ied)		
Forms of media								
Literature	Technical docu	umentation						

Workload Credit points Duration Frequency	ility
270 h 9 CP 1 semester every semester	ility
Module coordinator Lecturer(s) Dr. Nils Goerke Classification Programme Mode Semester M. Sc. Computer Science Optional 3. Technical skills Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will a these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, alto analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
Coordinator Lecturer(s) Dr. Nils Goerke Classification Programme Mode M. Sc. Computer Science Optional Science Optional Optional Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will at these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, altonomy to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
Lecturer(s) Dr. Nils Goerke Classification Programme M. Sc. Computer Science Mode Optional Opt	ility
Classification Programme M. Sc. Computer Science Optional Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will a these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, about to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
Classification M. Sc. Computer Science Optional 3. Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will a these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, about to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
Technical skills Students will acquire knowledge of the design and implementation of parallel algorithms on GPUs. They will a these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, about to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
implementation of parallel algorithms on GPUs. They will a these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, ab to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral ar written presentation of solutions, critical examination of implementations)	ility
these techniques to accelerate standard machine learning algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, about analyze problems and to find practical solutions), communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of implementations)	ility
algorithms for data-intensive computer vision tasks. Soft skills Self-competences (time management, goal-oriented work, alto analyze problems and to find practical solutions), communication skills (Work together in small teams, oral arwritten presentation of solutions, critical examination of implementations)	
Soft skills Self-competences (time management, goal-oriented work, at to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral ar written presentation of solutions, critical examination of implementations)	
to analyze problems and to find practical solutions), communication skills (Work together in small teams, oral ar written presentation of solutions, critical examination of implementations)	
communication skills (Work together in small teams, oral arwritten presentation of solutions, critical examination of implementations)	ıd
written presentation of solutions, critical examination of implementations)	
implementations)	
Contents Dasic matrix and vector computations with GLOS (CODA)	
Classification algorithms, such as multi-layer perceptrons,	
support-vector machines, k-nearest neighbors,	
linear-discriminant analysis. Image preprocessing and data	
handling. Quantitative performance evaluation of learning	
algorithms for segmentation and categorization.	
Prerequisites Recommended:	
At least 1 of the following:	
MA-INF 4111 – Intelligent Learning and Analysis Systems:	
Machine Learning	
MA-INF 4204 – Technical Neural Nets	
Teaching format Group size h/week Workload[h]	CP
Format Lab 8 4 60 T / 210 S	9
T = face-to-face teaching; $S = $ independent study	
	ided)
Study achievements (not gra	
Forms of media	<u>aca</u>
• R. Szeliski: Computer Vision: Algorithms and Application	
Springer 2010.	10,
Literature • C. M. Bishop: Pattern Recognition and Machine Learning	·.
Springer 2006.	17
• NVidia CUDA Programming Guide, Version 4.0, 2011.	

Module MA-INF 4309	Lab Sensor Data Interpretation						
Workload	Credit points	Credit points Duration Frequency					
270 h	9 CP	9 CP 1 semester at least every 2 years					
Module	PD. Dr. Volke	PD. Dr. Volker Steinhage					
coordinator							
Lecturer(s)	PD. Dr. Volke	er Steinhage	;				
Classification	Programme		Mode	Seme	nester		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	2. or 3.		
Technical skills	Competence to	Competence to implement algorithms for sensor data					
	interpretation, efficient handling and testing, documentation.					١.	
Soft skills	Efficient implementation of complex algorithms, abstract						
	thinking, documentation of source code.						
Contents	Varying select	Varying selected up-to-date topics on sensor data interpretation					
Prerequisites	Required:						
	All of the follo	owing:					
	MA-INF 2201	- Compute	er Vision				
	MA-INF 4206	- Selected	Topics in	Sensor Da	ata Interpretation	on	
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching	S = inde	ependent s	study		
Exam achievements	Oral presentat	ion, writte	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	Relevant litera	ture will b	announc	ed at star	t of the lab.		

Module	Lab Mobile	Robots	<u> </u>						
MA-INF 4310	Lab Woone	100000	•						
Workload	Credit points	Duration	1	Freque	encv				
270 h	9 CP	1 semes		_	st every y	ear			
Module	Prof. Dr. Svei		,,,,,		, , , , , , , , , , , , , , , , , , ,				
coordinator	2101. 21. 2.01	2 20111110							
Lecturer(s)	Prof. Dr. Sven Behnke, Dr. Nils Goerke								
	Programme								
Classification	M. Sc. Computer Science Optional 2. or 3.								
Technical skills	Participants acquire basic knowledge and practical experience in								
	the design and	l impleme	ntati	on of c	ontrol alg	orithms for simple	.e		
	structured rob	otic syste	ms u	sing re	al mobile	robots.			
	Fundamental j	paradigms	s for	mobile	robots w	ill be identified an	ıd		
	implemented i	n 2 persoi	n gro	ups.					
Soft skills	_	•		_	. –	iented work, abilit	ty		
		to analyze problems and to find practical solutions),							
		communication skills (Work together in small teams, oral and							
	written presentation of solutions, critical examination of								
~	implementatio		DOC	() 1	. 1 .	. , 1 1 .			
Contents		, –		* *		ion tools, basic			
	_	capabilities for mobile robots: reactive control, SMPA							
	· ·	architecture, navigation, path planning, localisation,							
	simultaneous localization and mapping (SLAM), visual based object detection, learning robot control.								
Prerequisites	Recommended		ıg roi	JOI COI	16101.				
Trerequisites	At least 1 of t		ng:						
	BA-INF 132 –		_	er Rob	otik				
		•	_						
	BA-INF 131 -								
	MA-INF 1314				nnıng				
	MA-INF 2201	– Compu	iter V	ision					
	MA-INF 4113	- Cogniti	ive R	obotics	3				
	MA-INF 4114	- Robot I	Learı	ning					
	MA-INF 4203	- Autono	mous	s Mobi	le System	S			
	Teaching forms			p size	h/week		$\overline{\mathbf{CP}}$		
Format	Lab			3	4	60 T / 210 S	9		
	T = face-to-fa	ce teachin	ng: S	= inde	pendent s	study			
Exam achievements	Oral presentat				I	(grade	$\overline{\mathrm{ed}}$		
Study achievements	1	,		1		(not grade			
Forms of media	Robots simula	tion envir	onmo	ents, ro	bot contr	ol middleware,			
	computer vision	on librarie	s, pre	ogramr	ning, dem	onstration of robo	ot		
	capabilities (re	eal robotic	c syst	extra cents), extra cents	presentati	on and written			
	report of appr								
			$\frac{1}{2}$	D. For	x: Probab	oilistic Robotics.			
	MIT Press, 20				_				
						ence, Published by	V		
Literature	Advanced Rob					_			
	B. Siciliano,		b (Eo	is.): Sp	oringer Ha	andbook of			
	Robotics, 2008			1 1.					
	• Additional S	tate-ot-th	ie-art	public	ations.				

Module MA-INF 4312	Semantic Data Web Technologies						
Workload	Credit points	Duration	Frequ	ency			
180 h	6 CP 1 semester every year						
Module	Prof. Dr. Jens Lehmann						
coordinator							
Lecturer(s)		Prof. Dr. Jens Lehmann, Dr. Christoph Lange, Dr. Maria Maleschkova					
G1 10 11	Programme	Programme Mode Semester					
Classification	M. Sc. Computer Science Optional 1.						
Technical skills	The goal of th			t knowledg	ge on the		
	fundamentals, technologies and applications of the Semantic						
	·	_			e lecture the ba		
				_	gies are explair		
Soft skills					-		
Contents	As part of the	W3C Sem	antic Web	initiative	standards and		
	technologies h	ave been d	eveloped for	or machine	-readable exch	ange	
	of data, inform		_				
	standards and	standards and technologies are increasingly being used in					
	applications ar	nd have alı	eady led t	o a numbe	r of exciting		
	projects (e.g.	DBpedia, s	emantic w	iki or com	mercial		
	applications su	ich as sche	ma.org, O	penCalais,	or Google's		
	Freebase). The	e module p	rovides a	heoretical	ly grounded an	ıd	
	practically orie	ented intro	duction to	this area.	The topics		
	discussed with	in the lect	ire include):			
	• RDF syntax	and data	model				
	• RDF Schema			cs of RDF	(S)		
	• ontologies in				` '		
	_				s, query langua	ges	
	• Linked Data			_		0	
	• Semantic tex						
Prerequisites	none				v		
-	Teaching forms	at	Group size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching	S = inde	1		1	
Exam achievements	Written exam		,, 5 - mac	Politiciti bi		ded)	
Study achievements	Successful exer	rcise partic	ipation		(not gra		
Forms of media		- 1100 Partite	- <u>r</u> ~~~~		(1100 810		
Literature							

Module MA-INF 4313	Seminar Sen	Seminar Semantic Data Web Technologies							
Workload	Credit points	Duration	1	Frequency					
120 h	4 CP	1 semes	ter	at least	every ye	ar			
Module	Prof. Dr. Jens	Lehmanr	1	'					
coordinator									
Lecturer(s)	Dr. Christoph	Dr. Christoph Lange, Dr. Maria Maleshkova							
Classification	Programme			Mode	Semest	ter			
Classification	M. Sc. Compu	iter Scienc	ce	Optional	$\lfloor 2.$				
Technical skills	Through the s	eminar, st	ude	nts will l	earn to w	ork with tools	and		
	technologies of	technologies of the Semantic Web as well as assess their							
	capabilities for	capabilities for given problems. They will gain the ability to							
	understand ne	understand new research results presented in original scientific							
	papers.								
Soft skills	Ability to pres	sent and to	o cr	itically d	iscuss tec	hnologies and			
	research result	s in the fr	ame	ework of	Semantic	Web technolog	gies.		
Contents	• technologies	such as tr	riple	stores, l	ink discov	very framework	ĸs,		
	NLP pipelines								
	• recent confe	rence and	joui	rnal pape	ers				
Prerequisites	none								
Format	Teaching forms	at	Gro	oup size	h/week	Workload[h]	CP		
Format	Seminar			10	2	30 T / 90 S	4		
	T = face-to-fa	ce teachin	ıg; S	s = indep	endent st	udy	· 		
Exam achievements	Oral presentat	tion, writte	en r	eport		(gra	ded		
Study achievements						(not gra	ded		
Forms of media									
Literature									

Module	Lab Semant	tic Data	Veb Tec	hnologi	es				
MA-INF 4314									
Workload	Credit points	Duration	Freque	ency					
270 h	9 CP	1 semeste	r every year						
Module	Prof. Dr. Jens	Lehmann							
coordinator									
Lecturer(s)	Prof. Dr. Jens	Prof. Dr. Jens Lehmann, Dr. Maria Maleschkova							
Classification	Programme		Mode	Seme	ster				
Classification	M. Sc. Compu	iter Science	Option	al 2 .					
Technical skills	The students v	The students will carry out a practical task (project) in the							
	context of Sen	context of Semantic Web technologies, including test and							
	documentation	documentation of the implemented software/system.							
Soft skills	Ability to prop	perly presei	t and def	end design	n decisions, to				
	prepare readal	ole docume	ntation of	software;	skills in				
	constructively	collaborati	ng with of	thers in si	mall teams over	a			
	longer period	of time; abi	lity to cla	ssify own	results with reg	gard			
	to the state-of	the-art							
Contents									
Prerequisites	none								
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP			
Format	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching	S = inde	ependent s	study				
Exam achievements	Oral presentat	ion, writter	report		(gra	ided)			
Study achievements					(not gra	ded			
Forms of media									
Literature									

Module MA-INF 4316	Graph Representat	tion Learn	ing								
Workload	Credit points Duratio	n Freque	ncy								
180 h	6 CP 1 semes	_	every 2 year	ars							
Module	Dr. Pascal Welke	<u>'</u>									
coordinator											
Lecturer(s)	Dr. Pascal Welke										
Classification	Programme	Mode	Semester								
	M. Sc. Computer Science	_	1.								
Technical skills	runtime of algorithms in - Ability to implement, p	representation and computational complexity, as well as practical runtime of algorithms in the context of machine learning applications. - Ability to implement, practically apply, and theoretically analyze graph representation, graph kernels, and graph mining algorithms.									
Soft skills	 Social, methodological, communication, own deve formulations, algorithms, Learning to solve project 	 Social, methodological, and analytical competences via communication, own development, and presentation of problem formulations, algorithms, and solutions. Learning to solve project tasks in a group. Learning to evaluate the trade-offs and limitations of existing methods. 									
Contents	We will discuss general a graph structured data. In representation learning su	particular, c	omputation	al methods for g	-						
	kernels, as well as graph mining techniques will be discussed, analyzed, and applied. Regarding GNNs and graph kernels, we will discuss the expressive power and how these concepts are related, as well as several specific examples. In the area of graph mining, we will likely investigate fast (approximate) algorithms to count small patterns, such as triangles, or trees.										
	If time permits, we might venture into the realm of ranking on large-scale graphs, with applications such as recommender systems. The exercises will focus on practical implementations and the application of these methods to real world examples.										
Prerequisites	Recommended: Helpful: one or more of t MA-INF 4111 – Intellig Learning MA-INF 4112 – Intellig Mining and Knowledge D MA-INF 4212 – Data S MA-INF 1105 - Algorit MA-INF 1102 - Combin	ent Learning ent Learning discovery cience and Bi hms for Data	and Analys g Data Analysis	·							
	Teaching format	Group size		Workload[h]	CP						
Format	Lecture	•	2	30 T / 45 S	2.5						
	Exercises		2	30 T / 75 S	3.5						
	T = face-to-face teaching	S = independent S = independent S	dent study		T = face-to-face teaching; S = independent study						
				(gr;							
Exam achievements	Oral exam or written exam (graded)										
	1	ipation	Successful exercise participation (not graded)								
Study achievements	1	ipation		(not git							
Exam achievements Study achievements Forms of media	Successful exercise partic Lecture slides Jupyter notebooks William L. Hamilton: Clectures on Artificial Interclaypool. Nils M. Kriege, Fredrik	Graph Represe	Machine Le	arning, Synthesi arning, Morgan	s and						
Study achievements	Successful exercise partic Lecture slides Jupyter notebooks William L. Hamilton: Clectures on Artificial Interclaypool. Nils M. Kriege, Fredrik on	Graph Represe and D. Johansson	Machine Le	arning, Synthesi arning, Morgan	s and						
Study achievements Forms of media	Successful exercise partic Lecture slides Jupyter notebooks William L. Hamilton: Claypool. Nils M. Kriege, Fredrik on graph kernels, Applied N	Graph Represe and D. Johansson etwork Science	Machine Le n, Christoph e 5(1):6.	arning, Synthesi arning, Morgan aer Morris: A su	s and						
Study achievements Forms of media	Successful exercise partic Lecture slides Jupyter notebooks William L. Hamilton: Clectures on Artificial Interclaypool. Nils M. Kriege, Fredrik on	Graph Represe and D. Johansson etwork Science	Machine Le n, Christoph e 5(1):6.	arning, Synthesi arning, Morgan aer Morris: A su	s and						
Study achievements Forms of media	Successful exercise partic Lecture slides Jupyter notebooks William L. Hamilton: Claypool. Nils M. Kriege, Fredrik on graph kernels, Applied N	Graph Represelligence and D. Johansson etwork Science M. Elisabett	Machine Le n, Christoph e 5(1):6. a Ghisu et a	arning, Synthesi arning, Morgan aer Morris: A su al.: Graph Kern	s and arvey						

Module MA-INF 4318	Seminar Representation Learning for Big Data Analytics					
Workload	Credit points Duration Frequency					
120 h	4 CP 1 semester every year					
Module	Prof. Dr. Emmanuel Müller					
coordinator						
Lecturer(s)	Prof. Dr. Emmanuel Müller					
` ,	Programme Mode Semester					
Classification	M. Sc. Computer Science Optional 2. or 3.					
Technical skills	Ability to understand new research results presented in original scientific papers.					
Soft skills	Ability to present and to critically discuss these results in the framework of the corresponding area.					
Contents	Smart representations (such as embeddings, kernels, and dimensionality reduction methods) are useful models that allow the abstraction of data within a well-defined mathematical formalism. The representations we aim at are conceptual abstractions of real world phenomena (such as social interactions, chemical reactions and biological processes) into the world of statistics and discrete mathematics in such a way that the powerful tools developed in those areas are available for complex analyses in a simple and elegant manner. The focus will be the understanding and comparison of smart					
	representations and their explicit/implicit data transformation models. We will study limitations and advantages of different techniques, and how the data representation changes the problem setup, reduces complexity, introduces robustness, or other valuable properties for big data analytics.					
Prerequisites	Recommended: Open-minded for new problem settings, Programming in different languages (C++, Python, Java), Critical approach to existing solutions, Research curiosity					
Format						
	T = face-to-face teaching; S = independent study					
Exam achievements	Oral presentation, written report (graded)					
Study achievements	(not graded)					
Forms of media						
	[1] Sergey Ivanov, Evgeny Burnaev. "Anonymous Walk Embeddings" ICML, 2018.					
	[2] Tsitsulin, Anton, Davide Mottin, Panagiotis Karras, and Emmanuel Müller "VERSE: Versatile Graph Embeddings from Similarity Measures." WWW, 2018.					
	[3] Yanardag, Pinar, and S. V. N. Vishwanathan. "Deep graph kernels." KDD, 2015.					
Literature	[4] Holger Dell, Martin Grohe, Gaurav Rattan "Lovász Meets Weisfeiler and Leman". ICALP, 2018					
	[5] Anton Tsitsulin, Davide Mottin, Panagiotis Karras, Alexander M. Bronstein, Emmanuel Müller "NetLSD: Hearing the Shape of a Graph". KDD, 2018					
	[6] Nino Shervashidze, Pascal Schweitzer, Erik Jan van Leeuwen, Kurt Mehlhorn, Karsten M. Borgwardt "Weisfeiler-Lehman Graph Kernels". JMLR, 2011					
	[7] Haochen Chen, Bryan Perozzi, Yifan Hu, Steven Skiena "HARP: Hierarchical Representation Learning for Networks". AAAI, 2018.					

Module MA-INF 4319	Game AI						
Workload 270 h	Credit points 9 CP	Duration 1 semester	Frequer every ye				
Module	Prof. Dr. Chris			zai			
coordinator	Fioi. Di. Chins	uan bauckn	age				
Lecturer(s)	Drof Dr Chris	tion Douglib	\ ma				
Lecturer(s)	Prof. Dr. Chris Programme	uan bauckna	Mode	G 4			
Classification		an Caianaa		Semester 2. or 3.			
m 1 1 1 1 1 1 1	M. Sc. Comput		Optional				
Technical skills	Upon completio						
			-	artificial in	telligence and h	ow	
	they apply to co						
	• know about b			hods for pla	nning, problem		
	solving, and bel		-				
				thms for pl	anning, problem	L	
	solving, and bel		0				
	• implement nu						
Soft skills				_	thmic foundation		
	_				and more advan		
	techniques for p			-	-		
		implement them on their own, and how to put them into practice specially in the context of artificial computer game agents.					
	- "			mputer gan	ne agents.		
Contents		• historical overview of game AI					
	• basic terms and definitions for AI in games						
	• backward induction and the minmax algorithm						
	• alpha-beta pruning, depth restircted searches, features, and						
	evaluation funct						
	• (traditional, u		ree search	algorithms			
	• Monte Carlo t						
	• algorithms for	-	_				
			computer	algorithms i	for data clusteri	ng	
	• self organizing		1 .	1 1. /			
	• finite state ma						
					g / programming	5	
	• probability th			vorks			
	Markov chains	,		1 1.	1 1 .		
	hidden Marko Markov dasisi						
	Markov decisi the Pollman						
	• the Bellman e • temporal diffe			iem iearning	3		
	• Q learning	rence learnii	ıg				
	• genetic algorit	hme and go	notic progr	amming			
Prerequisites	Recommended		ietic progr	amming			
Trerequisites			ar knowled	lge in linear	algebra, probab	sility	
	theory, and stat	-	-	-		71110 y	
	Teaching forma		Froup size		Workload[h]	CP	
Format	Lecture	10	noup size	11/ Week	60 T / 105 S	5.5	
romat	Exercises			2	30 T / 75 S	$\frac{3.5}{3.5}$	
		1		1	001/105	0.0	
	T = face-to-face	e teaching; S	= indeper	ndent study		1 1\	
Exam achievements	Oral exam	. ,	· ·		(0	aded)	
Study achievements	Successful exerc				(not gra	ided)	
Forms of media	• lecture slides				1	,.	
					ade available on	line	
	Russell and Nor	vig, "Artifici	al Intellige	ence: A Moo	iern Approach"		
Literature	Millington, "Art	ificial Intelli	gence For	Games"			
	MacKay. "Inform	nation Theo	rv. Inferen	ce, and Lea	rning Algorithm	s"	
		11100	.,,	oo, and near		~	

Module	Lab Repres	entation I	earning	on Gra	aphs			
MA-INF 4320								
Workload	Credit points	Duration	Freque	ncy				
270 h	9 CP	1 semester	every year					
Module	Prof. Dr. Emi	nanuel Müll	er					
coordinator								
Lecturer(s)	Prof. Dr. Emi	Prof. Dr. Emmanuel Müller						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optiona	1 2. or	3.			
Technical skills	The students	The students will carry out a practical task (project) in the						
	context of repr	context of representation learning on graphs, including test and						
	documentation	documentation of the implemented software/system.						
Soft skills	Ability to prop	perly present	and defe	nd design	n decisions, to			
	prepare readal	ole documen	tation of s	software;	skills in			
	constructively	collaboratin	g with oth	ners in sr	nall teams over	a		
	longer period	of time; abili	ty to class	sify ones	own results into	o the		
	state-of-the-ar	t of the resp	. area					
Contents								
Prerequisites	none							
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP		
Format	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching;	S = indep	pendent s	study			
Exam achievements	Oral presentat	ion, written	report		(gra	ded)		
Study achievements					(not gra	ded		
Forms of media								
Literature								

Module MA-INF 4321	Seminar Lea	Seminar Learning from Time Series						
Workload	Credit points	Duration	on Frequency					
120 h	4 CP	CP 1 semester every year						
Module	Prof. Dr. Emr	Prof. Dr. Emmanuel Müller						
coordinator								
Lecturer(s)	Prof. Dr. Emr	Prof. Dr. Emmanuel Müller						
Classification	Programme	Programme Mode Semester						
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.			
Technical skills	Ability to und	Ability to understand new research results presented in original						
	scientific paper	rs.						
Soft skills	Ability to pres	sent and to c	ritically di	scuss the	ese results in th	ne e		
	framework of t	the correspon	nding area	•				
Contents	Current confer	ence and jou	rnal pape	rs				
Prerequisites	none							
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
rormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa	ce teaching;	S = indep	endent st	udy			
Exam achievements	Oral presentat	ion, written	report		(gra	ded)		
Study achievements					(not gra	ded)		
Forms of media								
Literature								

Module	Lab Machin	e Learning	g on En	$\operatorname{cryptec}$	l Data		
MA-INF 4322							
Workload	Credit points	Duration	Freque	-			
270 h	9 CP	1 semester	every y	vear			
Module	Dr. Michael N	füsken					
coordinator							
Lecturer(s)	Dr. Michael N	lüsken					
Classification	Programme M. Sc. Compu	iter Science	Mode Optiona	1 2. or			
Technical skills	The students	will carry out	a practi	cal task ((project) in the	!	
	context of Cry	ptography, in	ncluding t	test and	documentation	of	
	the implement	ed software/s	system.				
Soft skills	Ability to prop	perly present	and defe	nd			
	design decision	ns. to prepare	readable	e docume	entation of soft	ware:	
		,				,	
		· ·	O		ners in small te		
	over a longer period of time; ability to classify ones own results						
	into the state-of-the-art of the resp. area						
	data science methodology to automatically analyze large amounts of possibly privacy infringing data we have to care understand how to protect our data. Also more and more f data shows up and we have to find ways to distinguish fake from trustable data. At the same time we want to allow insightful research and life-easing analyzes to be possible. It seeming contradiction has lead to various efforts for unifying both: protecting data and allowing analyzes, at least to some extent and possibly under some restrictions. See Munn et at (2019) for a review on challenges and options. The target of the lab is to understand how computations of encrypted data may work in one particular application that are chosing together. Ideally, we can come up with a novel solution for performing an unconsidered algorithm. We study the tasks and tools, select algorithms, find a protocol, protecting an unconsidered algorithms.						
	an implementi evaluation,	on, perform a	a security	analysis	s, present an		
Prerequisites	none						
	Teaching forms	at Gro	up size	h/week	Workload[h]	CP	
Format	Lecture			4	60 T / 105 S	5.5	
	Exercises			2	30 T / 75 S	3.5	
		ce teaching: 9	S = inder			1	
Even eshiorement-	T = face-to-fa Schriftliche Pr		5 — maet	bendent 8		aded)	
Exam achievements			m 0		, ,		
Study achievements	Erfolgreiche Ü	bungstennan	ше		(not gra	auea)	
Forms of media							
Literature							

Module MA-INF 4323	Pattern Rec	cognitio	on	(2)				
Workload	Credit points	Duratio		Frequ	-			
270 h Module	9 CP Prof. Dr. Christ	1 semes		every	year			
coordinator	Froi. Dr. Christ.	ian bauck	nage					
Lecturer(s)	Prof. Dr. Christ	ian Bauck	hage					
• • • • • • • • • • • • • • • • • • • •	Programme			ode	Sen	nester		
Classification	M. Sc. Compute	r Science	Op	tional	2. o	r 3.		
Technical skills	Upon completion	n, students	sho	uld be a	ble to)		
	 know about as practical implem algorithms know about ite with large data s implement num implement num 	entations erative algosets nerically re	of morith	achine l ms for r algorit t data c	earnii nachii hms f luster	ng / patterne learning for data diving and cl	rn recognition g / pattern recog mensionality red assification	nition uction
Soft skills	robust implemen pattern recogniti dynamical system	Students will learn about mathematical and algorithmic foundations of robust implementations of machine learning algorithms for data analysis and pattern recognition. They will learn about iterative algorithms and dynamical systems approaches in this area, how to implement them on their own, and how to put them into practice.						
Contents	 own, and how to put them into practice. advanced concepts from linear algebra QR-, spectral-, and singular value decompositions iterative algorithms for least squares optimization iterative algorithms for principal component analysis Hebbian learning and Oja's rule for principal compoentn analysis auto-encoder networks associative memory networks Hopfield networks Hopfield networks for pattern recognition Hopfield networks for problem solving energy minimization methods in machine learning and pattern recognition latent factor models for data analysis data matrix factorization techniques multidimensional scaling manifold learning basic graph theory graph cuts and graph clustering graph diffusion processes radial basis functions for interpolation 							
Prerequisites	• radial basis fur Recommended Students should theory, and statis Recognition (1).	l: good work stics. Idea	king l	knowled hey will	lge in l have	linear alge	the lecture Patt	ern
	Teaching form	at	G	roup si	ize	h/week	Workload[h]	CP
Format	Lecture					4	60 T / 105 S	5.5
	Exercises		 		,	2	30 T / 75 S	3.5
D 1.	T = face-to-face		S =	ındepen	dent	study		1 1
Exam achievements	Schriftliche Prüft						,-	raded)
Study achievements	Erfolgreiche Übu			1.1. 1.			(not gr	aded)
Forms of media						aro mada	available online	
Literature	 lecture slides are made available online lecture notes with programming examples are made available online MacKay, "Information Theory, Inference, and Learning Algorithms" Haykin, "Neural Networks and Learning Machines" Bishop, "Neural Networks for Pattern Recognition" Elden, "Matrix Methods in Data Mining and Pattern Recognition" Skillicorn, "Understanding Complex Datasets" Kirby, "Geometric Data Analysis" 							

Module MA-INF 4324	Seminar Ad	lvanced To	pics in I	Data Sc	ience		
Workload	Credit points	Duration	Frequen	Frequency			
120 h	4 CP	1 semester	1				
Module	Prof. Dr. Eler	Prof. Dr. Elena Demidova					
coordinator							
Lecturer(s)	Prof. Dr. Eler	na Demidova					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	ace Optional 2. or 3.		3.		
Technical skills	This module c	concentrates	on speciali	zed topic	s in data scien	ce.	
	The students of	obtain skills	in the inde	pendent,	, in-depth stud	y of	
	state-of-the-ar	t scientific li	terature or	specific	topics, discuss	ion	
	_	with their peers and presentation to the scientific audience.					
Soft skills		Communication skills: oral and written presentation of					
		scientific content.					
	• Self-compete		ility to ana	alyze pro	blems, time		
	management,						
Contents	Statistical and		_				
	,	0 0 2	-		science process:		
		, 0	, .	., .	tion, modelling	_	
		-	_		on and analytic	S	
	methods for sed domains.	elected data	types and	applicati	ons in specific		
Prerequisites	Recommended	:					
•	BA-INF 150 -	Einführung	in die Data	a Science)		
.	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = independent S	endent st	cudy	ı	
Exam achievements	Oral presentat	tion, written	report		(gra	ded)	
Study achievements	None				(not gra	ded)	
Forms of media							
Literature	Relevant litera	ature will be	announced	at the b	peginning of th	e	
плегатиге	seminar						

Module	Lab Data S	cience in	Practio	ee				
MA-INF 4325								
Workload	Credit points	Duration	Freq	iency				
270 h	9 CP	1 semest	er every	year				
Module	Prof. Dr. Eler	na Demido	va					
coordinator								
Lecturer(s)	Prof. Dr. Eler	na Demido	va					
Classification	Programme		Mode	Sem	ester			
Classification	M. Sc. Compu	e Optio	nal $\mid 2$. o	2. or 3.				
Technical skills	This module c	This module concentrates on practical experience in data						
	analytics. Par	ticipants a	cquire ba	sic knowle	edge and practica	al		
	experience in	the design	and imple	ementatio	on of data science)		
	workflows for	rorkflows for specific data types and applications.						
Soft skills	Communicate	• Communication skills: the ability to work in teams.						
	Self-compete	ences: the	ability to	analyse p	problems and find	l		
	practical solut	ions. Time	managei	nent, crea	ativity, presentat	ion		
	of results.							
Contents	Practical apple	ication of s	statistical	and mac	hine learning-bas	ed		
	methods to so	lve data ar	nalytics p	oblems o	n real-world data	asets		
	and evaluate p	proposed so	olutions.					
Prerequisites	Recommended	:						
	BA-INF 150 -	Einführun	g in die I	Oata Scien	nce			
	MA-INF 4230	- Advance	d Method	s of Infor	rmation Retrieva	l		
Format	Teaching forms	at C	Froup size	h/weel	Workload[h]	CP		
rormat	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching	g; S = inc	lependent	study			
Exam achievements	Oral presentat	ion, writte	n report		(gra	aded)		
Study achievements	None				(not gra	aded)		
Forms of media								
Literature								

Module MA-INF 4326	Explainable	AI an	d App	licati	ions			
Workload	Credit points	Duratio	n Fre	quen	ey .			
180 h	6 CP	1 semes	ter eve	ry yeai	•			
Module	Dr. Tiansi Dong							
coordinator	D D							
Lecturer(s)	Dr. Tiansi Dong		N	- C				
Classification	Programme M. Sc. Computer	r Science	Mode Options		emester			
Technical skills	• Know the dual-		_		human min	d. and two main	AI	
	paradigms • Develop white- • Understand the systems, and Kno Deep-Learning sy	box neura e problems ow the sta	l AI systes and lim	ems itation:	s of Blackbo	ox Deep-Learning		
Soft skills	 connectionist AI Develop neural symbolic AI and Know the limit self-driving. Kno Deep-Learning sy 	 Know System 1 and 2 of the mind, prons and cons of symbolic AI and connectionist AI Develop neural-geometric systems that have both good features of symbolic AI and connectionist AI Know the limitation of famous Deep-Learning systems, such as GPT3, self-driving. Know standard methods to explore the explainability of Deep-Learning systems 						
Contents	1. Introduction: self-driving cars							
	2. Dual-system theories (System 1 and 2), nine laws of cognition, criteria of semantic models							
	3. The target and the state-of-art methods of XAI							
	4. Neural-symbolic AI							
	5. Cognitive map	os, Collage	s, Menta	Spati	al Represen	tation, Events		
	6. Qualitative Spatial Representation and Reasoning							
	7. Rotating Sphere Embedding: A New Wheel for Neural-Symbolic Unification							
	8. Neural Syllogistic Reasoning							
	9. Recognizing Variable Environments							
	10. Humor Understanding							
	11. Rotating Spheres as building-block semantic components for Language, Vision, and Action							
Prerequisites	none							
	Teaching forms	at	Group	size	h/week	Workload[h]	CP	
Format	Lecture				2	30 T / 45 S	2.5	
	Exercises				2	30 T / 75 S	3.5	
T 1.	T = face-to-face	teaching;	S = inde	oenden	t study		1 1	
Exam achievements	Written exam	a mantiain	ation				raded)	
Study achievements Forms of media	Successiui exercis	se particip	ation			(not g	raded)	
Literature	 Successful exercise participation (not grade) Kahneman, D. (2011). Thinking fast and slow. Farrar, Straus and Girdese Gaedenfors, P. (2017). The Geometry of Meaning. MIT Press. Attardo, Hempelmann, Maio (2003). Script Oppositions and Logical Mechanisms: Modeling Incongruities and their Resolutions, HUMOR 15(1)3-46 Tversky, B. (2019). Mind in Motion. Basic Books, New York. Dong, et al. (2020). Learning Syllogism with Euler Neural-Networks. arXiv:2007.07320 Dong, T. (2021). A Geometric Approach to the Unification of Symbolic Structure and Neural Networks. Springer. Knauff and Spohn (2021). Handbook of Rationality. MIT Press, Cambridge, MA, USA. Samek et.al. (2019), Explainable AI: Interpreting, Explaining and Visualizing Deep Learning. Springer. Greg Dean (2019). Step by Step to Stand-Up Comedy (Revised Edition ISBN: 978-0-9897351-7-9 						s.	

Module MA-INF 4327	Lab Biomedical Data Science							
Workload	Credit points	Duration	Freque	Frequency				
270 h	9 CP	1 semeste	_	every year				
Module	Prof. Dr. Holger Fröhlich							
coordinator								
Lecturer(s)	Prof. Dr. Holg	ger Fröhlich						
CI 10 II	Programme	Mode	Seme	Semester				
Classification	M. Sc. Compu	iter Science	Option	al 3.	3.			
Technical skills	The students	will carry o	it a pract	ical task ((project) in the			
	context of biomedical data science, including test and							
	documentation of the implemented software/system.							
Soft skills	Ability to properly present and defend design decisions, to							
	prepare readable documentation of software; skills in							
	constructively collaborating with others in small teams over a							
	longer period of time; ability to classify ones own results into the							
	state-of-the-art of the resp. area							
Contents	Varying selected topics close to current research in the area of							
	biomedical data science.							
Prerequisites	none							
Format	Teaching forms	at G	oup size	h/week	Workload[h]	\mathbf{CP}		
rormat	Lab		8	4	60 T / 210 S	9		
	T = face-to-face teaching; $S = independent study$							
Exam achievements	Oral presentation, written report (graded)							
Study achievements	(not graded)							
Forms of media								
Literature								

Module MA-INF 4328	Spatio-Temporal Data Analytics							
Workload	Credit points	Duration	Frequer	Frequency				
180 h	6 CP	1 semeste	every year					
Module	Prof. Dr. Elena Demidova							
coordinator								
Lecturer(s)	Prof. Dr. Elena Demidova							
CI :C ::	Programme Mode			Semes	Semester			
Classification	M. Sc. Compu	Optional	2. or 3	2. or 3.				
Technical skills	This module is	ntroduces th	e students	to the ac	dvanced metho	ds,		
	data structure	data structures, and data analytics algorithms for						
	spatio-tempora	spatio-temporal data. At the end of the module, the students						
	will be capable of choosing appropriate data representations,							
	data structures and algorithms for specific applications and correctly applying relevant statistical and machine learning-based data analytics procedures.							
Soft skills	Communication skills: oral and written presentation and discussion of solutions. Self-competences: the ability to analyze and solve problems.							
Contents		-		,	ata representat			
	and analysis methods, and algorithms that enable analyzing spatio-temporal data and building predictive models effectively and effectively. Furthermore, we will study the corresponding							
	evaluation tech	hniques and	novel appl	ications.				
Prerequisites	none					I		
	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-face teaching; $S = independent study$							
Exam achievements	Schriftliche Prüfung (graded)							
Study achievements	Erfolgreiche Übungsteilnahme (not graded)				$\overline{\operatorname{ded}}$			
Forms of media								
Literature								

Module MA-INF 4329	Seminar Biological Intelligence						
Workload	Credit points Duration Frequency						
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Dr. Dominik Bach						
coordinator							
Lecturer(s)	Prof. Dr. Dr. I	Dominik Ba	ch				
Classification	Programme		Mode	Semest	Semester		
Classification	M. Sc. Computer Science Optional 2. or 3.						
Technical skills	Ability to understand new research results presented in original						
	scientific papers.						
Soft skills	Ability to present and to critically discuss these results in the						
	framework of the corresponding area.						
Contents	Current conference and journal papers.						
Prerequisites	none						
Format	Teaching format	t G1	oup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-face teaching; $S = independent study$						
Exam achievements	Oral presentation, written report (graded)						
Study achievements	(not graded)						
Forms of media							
Literature		·					

5 Master Thesis

MA-INF 0401	30 CP	Master Thesis	137
MA-INF 0402	2 CP	Master Seminar	138

Module MA-INF 0401	Master The	sis						
Workload	Credit points	Duration	on Frequency					
900 h	30 CP 1 semester every semester							
Module								
coordinator								
Lecturer(s)	All lecturers of computer science							
Classification	Programme		Mode	Se	Semester			
Classification	M. Sc. Compu			·				
Technical skills		Ability to solve a well-defined, significant research problem under supervision, but in principle independently						
Soft skills	Ability to write a scientific documentation of considerable length according to established scientific principles of form and style, in particular reflecting solid knowledge about the state-of-the-art in the field							
Contents	Topics of the thesis may be chosen from any of the areas of							
	computer science represented in the curriculum							
Prerequisites	none	none						
	Teaching format		Froup size	h/week		CP		
Format	Independent 0 90 preparation of a scientific thesis with individual coaching					30		
	T = face-to-face teaching; S = independent study							
Exam achievements	Master Thesis (graded)							
Study achievements	(not graded)							
Forms of media								
Literature	Individual bib relevant literat	~ .		-				

Module MA-INF 0402	Master Seminar						
Workload	Credit points	Duration	Freque	ncv			
60 h	2 CP	1 semester					
Module	2 ST I SOMESSOT STATE BEHINDOOF						
coordinator							
Lecturer(s)	All lecturers o	f computer s	cience				
CI :C .:	Programme				Semester		
Classification	M. Sc. Compu	iter Science	Compuls	sory 4.			
Technical skills	Ability to document and defend the results of the thesis work in						
	a scientifically appropriate style, taking into consideration the						
	state-of-the-art in research in the resp. area						
Soft skills							
Contents	Topic, scientific context, and results of the master thesis						
Prerequisites	none	none					
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar			2	30 T / 30 S	2	
	T = face-to-face teaching; $S = independent study$						
Exam achievements	Oral presentation of final results (graded)						
Study achievements	(not graded)						
Forms of media							
T:4	Individual bibliographic research required for identifying						
Literature	relevant literature (depending on the topic of the thesis)						