Module Handbook

for the

Master Programme "Computer Science"

at

Rheinischen Friedrich-Wilhelms-Universität Bonn

revised version: October 29, 2020

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.

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2	Graphics, Vision, Audio	31
3	Information and Communication Management	69
4	Intelligent Systems	101
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1 Algorithmics

MA-INF 110	2 L4E2	9 CP	Combinatorial Optimization	. 3
MA-INF 110	3 L4E2	9 CP	Cryptography	. 4
MA-INF 110	4 L4E2	9 CP	Advanced Algorithms	. 5
MA-INF 120	1 L4E2	9 CP	Approximation Algorithms	. 6
MA-INF 120	2 L4E2	9 CP	Chip Design	. 7
MA-INF 120	3 L4E2	9 CP	Discrete and Computational Geometry	. 8
MA-INF 120	5	6 CP	Graduate Seminar Discrete Optimization	. 9
MA-INF 120	6 Sem2	4 CP	Seminar Randomized and Approximation Algorithms $\ \ldots$	10
MA-INF 120	7 Lab4	9 CP	Lab Combinatorial Algorithms	
MA-INF 120	9 Sem2	4 CP	Seminar Advanced Topics in Cryptography	12
MA-INF 121	3 L4E2	9 CP	Randomized Algorithms and Probabilistic Analysis	13
MA-INF 121	7 Sem2	4 CP	Seminar Theoretical Foundations of Data Science	14
MA-INF 121	8 L4E2	9 CP	Algorithms and Uncertainty	15
MA-INF 121	9 Sem2	4 CP	Seminar Algorithmic Game Theory	16
MA-INF 122			·	
MA-INF 122	1 Lab4	9 CP	Lab Computational Analytics	18
MA-INF 122	2 Lab4	9 CP	Lab High Performance Optimization	19
MA-INF 130	1 L4E2	9 CP	Algorithmic Game Theory	20
MA-INF 130	4 Sem2	4 CP	Seminar Computational Geometry	21
MA-INF 130	5	6 CP	Graduate Seminar Chip Design	22
MA-INF 130			0	
MA-INF 130	8 Lab4	9 CP	Lab Algorithms for Chip Design	24
MA-INF 130	9 Lab4	9 CP	Lab Efficient Algorithms: Design, Analysis and	
			Implementation	25
MA-INF 131	2 L4E2	9 CP	The Art of Cryptography	
MA-INF 131			Online Motion Planning	
MA-INF 131	5 Lab4	9 CP	Lab Computational Geometry	28
MA-INF 132	0 Lab4	9 CP	Lab Advanced Algorithms	29
MA-INF 132	1 L2E2	6 CP	Binary Linear and Quadratic Optimization	30

Module	Combinator	rial Optim	ization					
MA-INF 1102								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP							
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	Option	al 1. or	2.			
Technical skills	Advanced know	Advanced knowledge of combinatorial optimization. Modelling						
	and developme	ent of solution	n strateg	gies for co	mbinatorial			
	optimization p	optimization problems						
Soft skills		Mathematical modelling of practical problems, abstract						
		chinking, 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:	Combinato	rial Opti	mization:	Polyhedra and			
Literature	Efficiency. Spr	ringer, 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 Pre	ss, 2011						

Module MA-INF 1103	Cryptograp	Cryptography						
Workload	Credit points	Duration	Frequ	onev				
270 h	9 CP 1 semester every year							
Module	Dr. Michael Nüsken							
coordinator	Di. Wilchael IV	doncii						
Lecturer(s)	Dr. Michael N	Dr. Michael Nüsken						
	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science		'- '				
Technical skills	-		_		sures, and of the	e		
		interplay between computing power and security requirements.						
	_ ~ ~	Mastery of the basic techniques for cryptosystems and						
	cryptanalysis							
Soft skills	Oral presentat	Oral presentation (in tutorial groups), written presentation (of						
					ving homework	`		
	problems, criti	ical assessn	ent					
Contents	Basic private-l	key and pu	olic-key cr	yptosyste	ms: AES, RSA,	ı		
	group-based. S	Security red	uctions.	Key excha	nge, cryptograp	$_{ m hic}$		
	hash functions	, signature	s, identific	cation; fac	toring integers a	and		
	discrete logari	thms; lower	bounds i	n structur	red models.			
Prerequisites	none							
	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	Written exam				(gra	ded)		
Study achievements	Successful exer	rcise partic	pation		(not gra	ded)		
Forms of media								
Literature	Stinson, CryCourse notes		Theory a	and Practi	ce, 2nd edition			

Module MA-INF 1104	Advanced A	Algorithm	ns				
Workload	Credit points	Duration	Frequ	uenc	v		
270 h	9 CP	1 semest	_		-		
Module	Prof. Dr. Heil	ko Röglin					
coordinator							
Lecturer(s)	Prof. Dr. Ann	e Driemel,	Prof. Dr	. Th	omas l	Kesselheim,	
	Prof. Dr. Heil	Prof. Dr. Heiko Röglin, PD Dr. Elmar Langetepe,					
	Dr. Herman H	Dr. Herman Haverkort, Senior Prof. Dr. Marek Karpinski					
Classification	Programme		Mode		Semes	ster	
Classification	-	M. Sc. Computer Science Optional 1.					
Technical skills		Deeper insights into selected methods and techniques of modern					
		algorithmics.					
Soft skills				hods	, critic	al discussion of	
	applied metho		•				
Contents	Advanced algo		-		٠.		
			-		_	rithms. We will	
		sential top	ics such a	s lin	ear pro	ograms and net	work
	flows.						
Prerequisites	none			1 -			I
	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	g; S = inc	leper	ndent s		
Exam achievements	Written exam					(gra	ded)
Study achievements	Successful exe	rcise partic	ipation			(not gra	ded)
Forms of media							
Literature							

			. 1					
Module	Approximat	tion Algori	thms					
MA-INF 1201	~		T =					
Workload	Credit points	Duration	Freque	-				
270 h	9 CP 1 semester at least every year							
Module	Prof. Dr. Jens	Prof. Dr. Jens Vygen						
coordinator								
Lecturer(s)		All lecturers of Discrete Mathematics,						
		Senior Prof. Dr. Marek Karpinski						
Classification	Programme	-	Mode	Seme				
	M. Sc. Compu		Optiona					
Technical skills	Introduction t	_			-			
		approximation algorithms for NP-hard combinatorial						
				_	es for proving lo	ower		
	and upper bou							
Soft skills				ds, critic	cal discussion of	'		
	applied metho		-					
Contents					on Schemes. De			
					or selected NP-l	nard		
	problems, like	,		-	'			
	MAXSAT, TS	· -						
	Facility Locati			_	=			
	techniques (lik							
	Search, randon		_					
	MCMC-Metho	* *			nalysis of			
	approximation		d PCP-S	ystems.				
Prerequisites	Recommended							
	Introductory l			ons of alg	gorithms and			
	complexity the				1	T		
	Teaching forms	at Gro	oup size	h/week	Workload[h]	CP		
Format	Lecture			4	60 T / 105 S	5.5		
	Exercises			2	$30 \mathrm{\ T} / 75 \mathrm{\ S}$	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								
	• S. Arora, C.	Lund: Hard:	ness of A	pproxima	ations. In:			
	Approximation							
	Hochbaum, ed	.), PWS, 199	06		`			
		,		approxi	mative Algorith	men		
	für harte Bere	chnungsprob	leme, Leo	cture Not	es (5th edition)	,		
Literature	Universität Bo	onn, 2007						
	• B. Korte, J.	Vygen: Com	binatoria	l Optimi	zation: Theory	and		
	Algorithms (6	th edition), S	pringer,	2018				
	• V. V. Vazira	ni: Approxir	nation A	lgorithms	s, Springer, 2001	1		
	• D. P. Willian	mson, D. B.	Shmoys:	The Desi	ign of			
	Approximation	n Algorithms	, Cambri	dge Univ	ersity Press, 20	11		

Module MA-INF 1202	Chip Design	n						
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every	year				
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. Computer Science Optional 1. or 2.						
Technical skills		Knowledge of the central problems and algorithms in chip						
			-		gorithms for so	_		
	_	eal-world problems, also with respect to technical constraints.						
	_	Techniques to develop and implement efficient algorithms for						
		very large instances. Mathematical modelling of problems occurring in chip design,						
Soft skills		_	_			gn,		
	_	development of efficient algorithms, abstract thinking,						
	_	presentation of solutions to exercises						
Contents		Problem formulation and design flow for chip design, logic synthesis, placement, routing, timing analysis and optimization						
-	, ,	ement, routi	ng, timin	g analysı	s and optimizat	tion		
Prerequisites	none		. 1		***	- CD		
	Teaching forms	at Gro	oup 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				
Exam achievements	Oral exam					aded)		
Study achievements	Successful exe	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,							
	Amsterdam 2011, pp. 33-96 • S. Held, J. Vygen: Chip Design. Lecture Notes (distributed							
	,		Design. I	∟ecture N	otes (distribute	ea		
	during the cou	,	C M4	in and I	V Colorfor	la .		
					.K. Scheffer, ed			
		_		-	nentation, Circu			
	pesign, and P	rocess techn	orogy. Cl	no Press	, 2nd edition, 2	010		

Module	Discrete an	d Comput	otional C	oomot	+ 10 % 7			
MA-INF 1203	Discrete an	u Comput	ational G	reome	ы 1 у			
Workload	Credit points	Duration	Frequenc	cy				
270 h	9 CP	1 semester	every ye	ar				
Module	Prof. Dr. Ann	e Driemel						
coordinator								
Lecturer(s)	Prof. Dr. Ann	Prof. Dr. Anne Driemel, PD Dr. Elmar Langetepe,						
	Dr. Herman H	Or. Herman Haverkort						
Classification	Programme		Mode	Seme	ster			
	M. Sc. Compu		Optional	1-4.				
Technical skills	0				cepts in the are			
		liscrete and computational geometry; design and analysis of						
	_			-	of the complex	ity		
	of geometric c	_			owledge			
	autonomously							
Soft skills	Social compet	`			_			
		olutions, goal-oriented discussions in teams), methodical						
	competence (a	. ,	, -	, ,				
	· ·	commitment :	and willing	ness to	learn, creativity	у,		
	endurance).	C		1.				
Contents				_	ms, hyperplane			
			_	_	tion, spanners,			
	_				n, VC-dimension	n,		
	epsilon-nets, v		,	_	٠,			
	randomized in			_	tric distance			
Duamaguisitas	problems in di		and mgne	Γ.				
Prerequisites	BA-INF 114 –		der algorit	hmisch	en Ceometrie			
	Teaching forms			/week	Workload[h]	CP		
Format	Lecture	at GIO	oup size 1	4	60 T / 105 S	5.5		
rormat	Exercises			2	30 T / 75 S	$\frac{3.5}{3.5}$		
			C • 1	_	'	3.5		
T	T = face-to-fa	ce teaching;	S = indepe	endent s		1 1\		
Exam achievements	Oral exam	. ,			, -	$\frac{\operatorname{ded}}{\operatorname{1}}$		
Study achievements	Successful exe	rcise particip	ation		(not gra	aea)		
Forms of media	T: : M /	1 T /	D: 1	<u> </u>				
	• Jiri Matouse							
	Graduate Text					- nle		
	• Mark de Bei Overmars. Co	· ·	<u> </u>		Kreveld, and Ma	лК		
Literature	Applications (-		_				
	978-3-540-779'		n). Springe	51. ISDI	N			
	• Narasimhan		netric Span	ner Not	works			
	·		_					
	• Klein, Concrete and Abstract Voronoi Diagrams							

Module	Graduate S	Graduate Seminar Discrete Optimization					
MA-INF 1205							
Workload	Credit points	Duration	Freque	ency			
180 h	6 CP	1 semester	every y	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	ıl 2.			
Technical skills	Competence to understand new research results based on						
	original literat	original literature, to put such results in a broader context and					
	present such re	present such results and relations.					
Soft skills	Ability to read	and unders	tand rese	arch pape	ers, abstract		
	thinking, prese	entation of n	athemati	ical result	ts in a talk		
Contents	A current rese	arch topic in	discrete	optimiza	tion will be cho	sen	
	each semester	and discusse	d based o	on origina	al literature.		
Prerequisites	Recommended	:					
	MA-INF 1102	- Combinat	orial Opt	imization			
T3 4	Teaching forms	at Gre	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							
T *4	The topics and the relevant literature will be announced towards						
Literature	the end of the previous semester.						

Module MA-INF 1206	Seminar Randomized and Approximation Algorithms						
Workload	Credit points	Duration	1	Freque	ncy		
120 h	4 CP	4 CP 1 semester every year					
Module	Prof. Dr. Heik	Prof. Dr. Heiko Röglin					
coordinator							
Lecturer(s)	Prof. Dr. Anne Driemel, Prof. Dr. Thomas Kesselheim,						
	Prof. Dr. Heik	Prof. Dr. Heiko Röglin, PD Dr. Elmar Langetepe,					
	Dr. Herman H	laverkort,	Sen	ior Prof.	Dr. Mar	ek Karpinski	
CI 'C '	Programme			Mode	Semest	ter	
Classification	M. Sc. Computer Science Optional 2.						
Technical skills	Ability to perform individual literature search, critical reading,						
	understanding	, and clea	r pr	esentatio	n.		
Soft skills	Presentation o	f solution	s an	d metho	ds, critica	l discussion of	
	applied method	ds and tec	chni	ques			
Contents	Current topics	in design	and	d analysis	s of rando	mized and	
	approximation	algorithm	ns b	ased on l	lastest res	search literatur	e
Prerequisites	none						
TD 4	Teaching forms	at	Gro	oup size	h/week	Workload[h]	CP
Format	Seminar			10	2	30 T / 90 S	4
	T = face-to-face	ce teachin	ıg; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writt	en r	eport		(gra	ded)
Study achievements		(not graded)					
Forms of media							
Literature	The relevant li	terature v	will	be annou	inced in t	ime.	

Module	Lab Combin	natorial Al	gorithn	ns				
MA-INF 1207								
Workload	Credit points	Duration	Frequency					
270 h	9 CP							
Module	Prof. Dr. Jens	s Vygen						
coordinator								
Lecturer(s)	All lecturers of Discrete Mathematics							
Classification	Programme		Mode	Semes	ster			
Classification	M. Sc. Compu	iter Science	Optiona	d 2.				
Technical skills	Competence to	Competence to implement advanced combinatorial algorithms,						
	handling nonti	handling nontrivial data structures, testing, documentation.						
	Advanced soft	Advanced software techniques.						
Soft skills	Efficient imple	ementation of	complex	algorith	ms, abstract			
	thinking, docu	mentation of	source c	ode				
Contents	Certain combi	natorial algo	rithms w	ill be cho	sen each semest	er.		
	The precise ta	sk will be ex	plained in	n a meeti	ng in the previo	ous		
	semester.							
Prerequisites	Recommended	:						
	MA-INF 1102	- Combinato	orial Opti	imization				
TD 4	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	ded)		
Forms of media								
T:44	The topics and the relevant literature will be announced towards							
Literature	the end of the previous semester							

Module	Seminar Ad	Seminar Advanced Topics in Cryptography						
MA-INF 1209								
Workload	Credit points	Duration	ı	Frequer	ıcy			
120 h	4 CP 1 semester every semester							
Module	Dr. Michael N	üsken	,					
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	Distilling this into a presentation. Determination of relevant vs.						
	irrelevant mat	relevant material. Developing a presentation that fascinates						
	fellow students	fellow students.						
Soft skills	_	_		_		orally and in v	isual	
	media. Motiva	_			participa	te. Critical		
	assessment of							
Contents			-	0 2 0,		g from year to	year,	
	is studied in d	epth, base	ed or	current	research	literature		
Prerequisites	Required:							
	MA-INF 1103	- Cryptos	grap	hy				
	and one further	er course i	n cry	yptograp	hy like T	he Art of		
	Cryptography	or eSecur	ity.					
Format	Teaching forms	at	Gro	up size	h/week	Workload[h]	CP	
rormat	Seminar			10	2	30 T / 90 S	4	
	T = face-to-fa	ce teachin	ıg; S	= indep	endent st	cudy		
Exam achievements	Oral presentat		<u> </u>				ded)	
Study achievements	_	· · · · · · · · · · · · · · · · · · ·				(not gra	ded)	
Forms of media						<u> </u>		
Literature	Current confer	rence publ	licati	ons, to b	e annour	nced in time		

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}		
	analysis of alg	analysis of algorithms as well as for the design and analysis of randomized algorithms						
Soft skills		Oral and written presentation of solutions and methods,						
		abstract thinking						
Contents		Design and analysis of randomized algorithms						
		• complexity classes						
	Markov chains and random walks							
	• tail inequalit		m wang					
	• probabilistic							
	1							
	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 Th	Seminar Theoretical Foundations of Data Science					
Workload	Credit points	Duration	Frequen	ıcv			
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Heiko Röglin						
coordinator							
Lecturer(s)	Prof. Dr. Anne Driemel, Prof. Dr. Thomas Kesselheim,						
. ,	Prof. Dr. Heil	Prof. Dr. Heiko Röglin, PD Dr. Elmar Langetepe,					
	Dr. Herman Haverkort						
CI 'C '	Programme		Mode Semeste		er		
Classification	M. Sc. Computer Science		Optional	2. or 3	2. or 3.		
Technical skills	Ability to understand new research results presented in original					inal	
	scientific pape	scientific papers.					
Soft skills	Ability to pres	sent and to c	ritically di	scuss the	ese results in th	ıe	
	framework of	the correspon	nding area				
Contents	Current confer	rence and jou	ırnal pape	rs			
Prerequisites	none						
Format	Teaching form	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	tion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module	Algorithms	and Unce	rtainty				
MA-INF 1218							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	ester at least every 2 years				
Module	Prof. Dr. Tho	mas Kesselh	eim				
coordinator							
Lecturer(s)	Prof. Dr. Tho	Prof. Dr. Thomas Kesselheim					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Computer Science Options			al 2. or	3.		
Technical skills	Understanding	Understanding approaches for modeling uncertainty in					
	algorithmic th	algorithmic theory. Designing and analyzing algorithms with					
	performance guarantees in the context of uncertainty.						
Soft skills	Oral and writt	Oral and written presentation of solutions and methods					
Contents	• Advanced O	nline Algorit	$_{ m hms}$				
	• Markov Dec	isions Proces	ses				
	• Stochastic and	nd Robust O	ptimizat	ion			
	• Online Learn	ning Algorith	ms and	Online Co	onvex Optimizat	tion	
	• Sample Com	plexity					
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							
Literature	lecture notes, research articles						

Module MA-INF 1219	Seminar Algorithmic Game Theory						
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	1 semeste	r every y	ear			
Module	Prof. Dr. Thomas Kesselheim						
coordinator							
Lecturer(s)	Prof. Dr. Tho	mas Kessell	neim				
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	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 perf	Ability to perform individual literature search, critical reading,					
	and clear dida	ctic present	ation				
Contents	Advanced topi	_			_	mic	
	Mechanism De	esign based	on current	conference	e and journal		
	papers						
Prerequisites	none						
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Tormat	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	ided)	
Study achievements					(not gra	ided)	
Forms of media							
Literature							

Module MA-INF 1220	Seminar Al	gorithms	for Comp	outation	al Analytic	S
Workload	Credit points	Duration	Frequen	ıcy		
120 h	4 CP	1 semeste				
Module	Prof. Dr. Petra Mutzel					
coordinator						
Lecturer(s)	Prof. Dr. Peti	a Mutzel				
Classification	Programme		Mode	Semest	ter	
Classification	M. Sc. Computer Science Optiona			2. or 3	3.	
Technical skills	Ability to perf	Ability to perform individual literature search, critical reading,				
	understanding	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 algorithi	ns for com	putationa	al analytics bas	sed
	on recent research	arch literatu	re.			
Prerequisites	Recommended	:				
	Interest in Alg	gorithms				
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP
Tormat	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	ided)
Study achievements					(not gra	ided)
Forms of media						
Literature	The relevant l	iterature wi	l be annou	nced in t	ime.	

Module MA-INF 1221	Lab Compu	tational	Analytic	S			
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste	er every	every year			
Module	Prof. Dr. Petr	a Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Petr	a Mutzel					
Classification	Programme		Mode	Seme	ster		
	M. Sc. Compu	iter Science	Option	al 2. or	3.		
Technical skills	computational	Ability to design, analyze and implement efficient algorithms for computational analytics problems. The LAB also includes experimental evaluation and documentation of the implemented software					
Soft skills		ole docume collaborati of time; abi	ntation of ng with ot lity to clas	software; thers in si			
Contents	Design of efficient structures for			-	gorithms and da ems.	ıta	
Prerequisites	Recommended	:					
	Interests in alg	$_{ m gorithms}$					
Format	Teaching forms	at G	oup 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, writter	report		(gra	ded)	
Study achievements					(not gra	ided)	
Forms of media					-		
Literature	The relevant l	iterature w	ll be anno	ounced in	time.		

Module	Lab High P	erformand	e Optin	nization	<u> </u>		
MA-INF 1222							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	er every year				
Module	Prof. Dr. Petr	a Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Petr	a Mutzel, D	r. Sven N	Iallach			
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	2. or 3.		
Technical skills	Ability to desi	Ability to design, analyze and implement efficient algorithms for					
	computational	computational analytics problems. The lab also includes					
	experimental e	evaluation a	nd docum	entation	of the implemen	$_{ m ted}$	
	software.						
Soft skills	Ability to prop	perly presen	and defe	nd design	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	ded)	
Study achievements					(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature	The relevant l	iterature wil	l be anno	unced in	time.		

Module	Algorithmic	Game Tl	neory				
MA-INF 1301							
Workload	Credit points	Duration	Freque	-			
270 h	9 CP	1 semester		2 years			
Module	Prof. Dr. Tho	mas Kessein	eım				
coordinator	Df D. Tl	T/ 11-	_•				
Lecturer(s)	Prof. Dr. Tho		,				
	Senior Prof. D	r. Maiek K	Mode	Seme	at on		
Classification				I			
Technical skills			_		methods related to	<u> </u>	
remilear skins		-		-		0	
	the Game Theory for analyzing modern Internet-based communication networks and for designing algorithms for the						
					resource allocation	on.	
					natorial auctions,	- ,	
	and the netwo		_	,	,		
Soft skills	Presentation of	f solutions a	nd metho	ods, critic	cal discussion of		
	applied metho						
Contents	The most defining characteristic of the Internet is that						
	not designed by a single central entity, but emerged from the						
	complex interactions of many individual entities or economic						
	agents, such as network operators, service providers, designers,						
	users, etc. We aim at providing basic framework and basic						
	techniques for analyzing and designing algorithms for the						
	following Internet-related problems and contexts: game theoretic						
	problems connected to the Internet and other decentralized						
	networks, resource allocation, mechanism design, Nash and						
	market equilibria, network economics, combinatorial auctions, cost allocations and network design.						
					and unifying tashniques		
					unifying technique		
	that have emerged recently in the above areas and discuss new fundamental paradigms in design of the relevant algorithms.						
D 114			design of	tne reiev	vant algorithms.		
Prerequisites	Recommended Introductory k		foundati	ong of ale	rorithms and		
	complexity the	_		ons or are	gorrinns and		
	Teaching forms		oup size	h/week	Workload[h]	CP	
Format	Lecture	at GI	Jup size	4		$\frac{5.5}{5.5}$	
Tormat	Exercises			2	1 '	3.5	
		oo too ohimm	c inde			0.0	
Even eshiowers	T = face-to-fa Written exam	ce teaching;	s = mae	репаент		047	
Exam achievements	Successful exe	rcisa particir	ation		(grade (not grade		
Study achievements Forms of media	Successiui exe.	icise particij	auton		(not grade	eu)	
rorms or media	• D P Rortso	kas A Nadi	с А Е	Ozdadari	Convex Analysis	1	
		,	,	ozuagiai.	Convex Analysis	,	
	and Optimization, Athena, 2003 • M. Karpinski, W. Rytter: Fast Parallel Algorithms for Graph						
	Matching Problems, Oxford Univ. Press, 1998						
	• D. M. Kreps: A Course in Microeconomic Theory, Princeton						
Literature	Univ. Press, 1						
			en, E. Ta	rdos, V.V	V. Vazirani (ed.):		
	• N. Nisan, T. Roughgarden, E. Tardos, V.V. Vazirani (ed.): Algorithmic Game Theory, Cambridge Univ. Press, 2007						
	• M. J. Osborne, A. Rubinstein: A Course in Game Theory,						

Module	Seminar Co	mputati	ona	l Geon	netry		
MA-INF 1304							
Workload	Credit points	Duration		Frequen	cy		
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Ann	Prof. Dr. Anne Driemel					
coordinator							
Lecturer(s)	Prof. Dr. Ann	e Driemel,	, PD	Dr. Elr	nar Lang	etepe,	
	Dr. Herman H	Dr. Herman Haverkort					
Classification	Programme		I	Mode	Semest	ter	
	M. Sc. Compu	iter Scienc	e (Optional	2-4.		
Technical skills	To independen	To independently study problems at research level, based on					
	research public	research publications, to prepare a concise summary, to present					
	the summary i	in a scienti	ific t	alk, to le	ead a crit	ical discussion	
	with other sen	ninar parti	cipa	nts.			
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	ojector, bl	ack	board.			
Literature	The relevant li	iterature w	rill b	e annou	nced.		

Module	Graduate Seminar Chip Design						
MA-INF 1305			1_				
Workload	Credit points	Duration	Freque	ency			
180 h	6 CP	1 semester	eter every year				
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	Optiona	al 3.			
Technical skills	Competence to	Competence to understand new theoretical results and practical					
	solutions in V	solutions in VLSI design and related applications, as well as					
	presentation of such results						
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	- Combinate	orial Opt	imization			
	MA-INF 1202	- Chip Desi	gn				
Format	Teaching forms	at Gro	up 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 end of the			re will be	announced tow	vards	

Module MA-INF 1307	Seminar Ad	Seminar Advanced Algorithms					
Workload	Credit points	Duration	Freque	ncy			
120 h	4 CP	1 semeste	_	•			
Module	Prof. Dr. Tho	mas Kessel	neim				
coordinator							
Lecturer(s)	Prof. Dr. Ann	Prof. Dr. Anne Driemel, Prof. Dr. Thomas Kesselheim,					
	Prof. Dr. Heil	ko Röglin, F	D Dr. Eln	nar Lange	etepe,		
	Dr. Herman Haverkort						
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona	1 3.	3.		
Technical skills	Presentation of selected advanced topics in algorithm design and					and	
	various applica	ations					
Soft skills	Ability to perf	orm individ	ual literat	ure search	ı, critical readi:	ng,	
	understanding	, and clear	didactic pr	esentation	n		
Contents	Advanced topi	cs in algori	hm design	based on	newest research	ch	
	literature						
Prerequisites	none						
Format	Teaching forma	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	oendent st	tudy		
Exam achievements	Oral presentat	ion, writter	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	The relevant li	iterature wi	ll be anno	ınced in t	ime.		

Module	Lab Algorit	Lab Algorithms for Chip Design					
MA-INF 1308							
Workload	Credit points	Duration	Freque	-			
270 h	9 CP	1 semester	every	year			
Module	Prof. Dr. Jens	s Vygen					
coordinator							
Lecturer(s)		All lecturers of Discrete Mathematics					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Computer Science		Optiona	al 3.			
Technical skills	_		_		SI design, efficient	ent	
	handling of ve	handling of very large instances, testing, documentation.					
	Advanced soft	Advanced software techniques.					
Soft skills	Efficient imple	Efficient implementation of complex algorithms, abstract					
	thinking, mode	thinking, modelling of optimization 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 relevant literature will be announced towards						
Literature	the end of the	previous ser	nester				

Module	Lab Efficien	Lab Efficient Algorithms: Design, Analysis and						
MA-INF 1309	Implementa	tion						
Workload	Credit points	Credit points Duration Frequency						
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	Dr. Herman Haverkort						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	ter Science	Options	al 3.				
Technical skills	Ability to desi	Ability to design, analyze and implement efficient algorithms for						
	selected comp	selected computational problems.						
Soft skills	ability to work on advanced algorithmic implementation							
	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	The Art of Cryptography							
MA-INF 1312								
Workload	Credit points	Duration	Frequency					
270 h	9 CP	1 semeste	r every year					
Module	Dr. Michael Nüsken							
coordinator								
Lecturer(s)	Dr. Michael N	Dr. Michael Nüsken						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	Option	al 2 .					
Technical skills	Insights into t	Insights into the theoretical foundations behind security						
	concerns and i	concerns and measures, and of the interplay between computing						
	power, and sec	ower, and security requirements. Mastery of advanced						
	techniques for	sechniques for cryptosystems and cryptanalysis.						
Soft skills	Oral presentation (in tutorial groups), written presentation (of							
	exercise solution	ons), team of	ollaborat	ion in sol	ving homework			
	problems, criti	ical assessme	ent					
Contents	Possible topics	s are						
	• pseudorando	mness and	zero-know	rledge.				
	• security redu			() -)				
	• lattices.	,						
Prerequisites	Recommended	:						
_	MA-INF 1103	- Cryptogra	aphy					
	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	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise partici	oation		(not gra	ded)		
Forms of media								
Literature	Varying							

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	cellular environments, polygons, strets), online 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 of geometry lab						
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	ncv				
270 h	9 CP							
Module	Prof. Dr. Ann	e Driemel						
coordinator								
Lecturer(s)	Prof. Dr. Ann	e Driemel, F	D Dr. Eli	nar Lan	getepe,			
	Dr. Herman H	Dr. Herman Haverkort						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optional	$oxed{2}$.	2.			
Technical skills	Ability to design, analyze, implement and document efficient							
	algorithms for	algorithms for selected problems in computational geometry.						
Soft skills	Ability to properly present, defend and discuss design and							
	implementatio	n decisions,	to docume	ent softw	are according t	О		
	given rules and	d to collabor	ate with c	ther stu	dents in small			
	groups.							
Contents	Various proble	ems in comp	ıtational g	geometry	·.			
Prerequisites	none							
Format	Teaching forms	at Gre	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	tion, written	report		(gra	ided)		
Study achievements					(not gra	ided)		
Forms of media								
Literature	The relevant l	iterature will	be annou	inced in	time.			

Module MA-INF 1320	Lab Advanced Algorithms						
Workload	Credit points Duration Frequency						
270 h	9 CP	1 semester					
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 of algorithms from advanced algorithmic theory,						
	evaluating these algorithm on suitably chosen instances, and						
	discussing how	discussing how theoretical results transfer 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 Linear and Quadratic Optimization							
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 Mall	Dr. Sven Mallach						
Classification	Programme	Programme Mode Semester						
Classification	M. Sc. Compu	iter Science	Optiona	$1 \mid 2$. or 3	3.			
Technical skills	Deeper understanding of computational methods to solve							
	potentially large-scale mixed-integer programs in practice.							
	Application-sp	ecific mode	lling and r	eformulat	ion of			
	combinatorial	combinatorial optimization problems, handling quadratic						
	objective funct	objective functions, algorithm design.						
Soft skills	Social, methodological, and analytical competences via							
	communication, own development, presentation, and critical							
	assessment of	assessment of problem formulations, algorithms, and solutions						
	covered in the	course or t	he excercise	es. Learni	ing to abstract	, but		
	also learning the limitations of abstraction.							
Contents	_		,		ogramming su			
	cutting plane s	-			_			
	short and acce							
					d binary quadr			
	optimization p					_		
	and variants o		_	_	. –			
	particular sepa	_		_		e,		
	linearizations	_	-					
	sophisticated f	ormulation	s of binary	quadratio	c problems are			
	discussed.							
Prerequisites	none				T	T		
_	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							
Exam achievements	Oral exam (de	fault, possi	bly change	d to writt	en exam durin	g		
	the term)				(gra	ided)		
Study achievements	Successful exer	rcise partic	pation		(not gra	ided)		
Forms of media								
Literature								

2 Graphics, Vision, Audio

MA-INF 2111	L2E2	6 CP	Foundations of Graphics	32
MA-INF 2113	L2E2	6 CP	Foundations of Audio Signal Processing	33
MA-INF 2201	L4E2	9 CP	Computer Vision	34
MA-INF 2202	L4E2	9 CP	Computer Animation	35
MA-INF 2203	L4E2	9 CP	Selected Topics in Signal Processing	36
MA-INF 2204	L2E2	6 CP	Rendering Techniques I	37
MA-INF 2205	L2E2	6 CP	Geometry Processing I	38
MA-INF 2206	Sem2	4 CP	Seminar Vision	39
MA-INF 2207	Sem2	4 CP	Seminar Graphics	40
MA-INF 2208	Sem2	4 CP	Seminar Audio	41
MA-INF 2209	L4E2	9 CP	Advanced Topics in Computer Graphics I	42
MA-INF 2210	Sem2	4 CP	Seminar Computer Animation	43
MA-INF 2212	L2E2	6 CP	Pattern Matching and Machine Learning for Audio Signa	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 2302	L2E2	6 CP	Physics-based Modelling	55
MA-INF 2304	L2E2	6 CP	Rendering Techniques II	56
MA-INF 2305	L2E2	6 CP	Geometry Processing II	57
MA-INF 2306	L2E2	6 CP	Virtual Reality	58
MA-INF 2307	Lab4	9 CP	Lab Vision	59
MA-INF 2308	Lab4	9 CP	Lab Graphics	60
MA-INF 2309	Lab4	9 CP	Lab Audio	61
MA-INF 2310	L4E2	9 CP	Advanced Topics in Computer Graphics II	62
MA-INF 2311	Lab4	9 CP	Lab Computer Animation	63
MA-INF 2312	L3E1	6 CP	Image Acquisition and Analysis in Neuroscience	64
MA-INF 2313	L2E2	6 CP	Deep Learning for Visual Recognition	
MA-INF 2314	L4E2	9 CP	Image Processing, Search and Analysis I	66
MA-INF 2315	L4E2	9 CP	Seminar Computational Photography	67
MA-INF 2316	L4E2	9 CP	Lab Digital Material Appearance	

Module MA-INF 2111	Foundations of Graphics						
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semeste	r every y	every year			
Module	Prof. Dr. Reinhard Klein						
coordinator							
Lecturer(s)	Prof. Dr. Reir	nhard Klein,	Prof. Dr.	Andreas	Weber,		
	Prof. Dr. Mat	thias Hullin					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optiona	$l \mid 1. \text{ or } 2$	2.		
Technical skills	Knowledge of	basic mathe	matical te	chniques of	commonly used	l in	
	Graphics with	a strong en	nphasis on	their app	lication to real		
	world problem						
Soft skills	Research abilit	Research abilities, information retrieval abilities, collaboration					
	abilities, self n						
Contents	_	•		_	plications to in	_	
	formation (rig	·	,		, ,		
					nodelling; Ordi	nary	
	differential equ	ations with	application	ns to phy	sical based		
	modelling						
Prerequisites	Required:	D 1	6.0	1. 77.	1 4 1	,	
	MA-INF 2101		ns of Grap	ohics, Visi	on and Audio	has	
	not been passe						
.	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			
Exam achievements	Written exam				,,,	ded)	
Study achievements	Successful exe	rcise partici	pation		(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 2113	Foundations of Audio Signal Processing						
Workload	Credit points	Duration	Freq	uenc	y		
180 h	6 CP	1 semest	ter ever	every year			
Module	apl. Prof. Dr. Frank Kurth						
coordinator							
Lecturer(s)	apl. Prof. Dr.	Frank Ku	rth, Prof.	Dr.	Michae	el Clausen	
Classification	Programme		Mode		Semest	ter	
Classification	M. Sc. Compu	iter Scienc	e Optio	$_{\mathrm{nal}}$	1.		
Technical skills	• Introduction	to basic o	concepts of	f an	alog and	d digital signal	
	processing;						
	• Applications in the field of Audio Signal Processing;						
	• Signal Proce	• Signal Processing Algorithms;					
	• Implementing	• Implementing basic Signal Processing Algorithms					
Soft skills		Solving basic Signal Processing Problems; Implementing Signal					
	Processing Alg	gorithms u	sing state	-of-t	he-art s	oftware	
	frameworks; C	Capability t	to analyze	; Ti	me man	agement;	
	Presentation s	kills; Discı	ussing ow	n sol	lutions a	and solutions of	f
	others, and wo						
Contents			,	,		Signal Process	sing;
	Fourier Transf	,				, ,	
	Filters; Audio	_	_			,	
	Windowed For	urier Trans	sform; 2D	-Sigi	nal Proc	essing	
Prerequisites	none						
	Teaching forms	at	Group siz	e l	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 = inc	lepe	ndent st	udy	
Exam achievements	Written exam					(gra	ded)
Study achievements	Successful exe	rcise partic	cipation			(not gra	ded)
Forms of media	Slides, Blackb	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. Jürgen Gall							
coordinator								
Lecturer(s)	Prof. Dr. Jürg	Prof. Dr. Jürgen Gall						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 1. or 2.						
Technical skills	Students will l	earn about v	arious m	athemati	cal methods and	d		
	their applications to computer vision problems.							
Soft skills	Productive work in small teams, development and realization of							
	individual approaches and solutions, critical reflection of							
	competing me	,		-				
Contents		The class will cover a number of mathematical methods and						
		_			ample, linear fil			
	,	, –		, –	tation, graph cu	ıts,		
	mean shift, ac		,	,	_			
					oral filtering, a			
		, -	_	,	tracking, camera	,		
					pose estimation			
			, deform	able mesh	nes, RGBD visio	on.		
Prerequisites	Recommended							
		_	lgebra, a	nalysis, p	orobability theo	ry,		
	C++ program				T			
	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			
Literature	Computer Vis							
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 MA-INF 2202	Computer Animation								
Workload	Credit points	Duration	Freque	nev					
270 h	9 CP	1 semester	every	-					
Module	Prof. Dr. And		overy .	your					
coordinator	1 101. D1. 11110	1 tol. Dr. Andreas weber							
Lecturer(s)	Prof. Dr. And	lreas Weber							
Lecturer (b)	Programme								
Classification	M. Sc. Compu	iter Science	Optiona		3601				
Technical skills	_		-		sed in compute	r			
Technical skins		Students will learn fundamental paradigms used in computer animation. They will learn to use mathematical models of							
		· ·			ns of problems of	of			
		-	_		-	<i>J</i> 1			
Soft skills	· ·	the synthesis of motions of virtual characters. Social competences (work in groups), communicative skills							
SOIT SKIIIS	(written and oral presentation)								
Contents		Fundamentals of computer animation; kinematics;							
Contents		representations of motions; motion capturing; motion editing;							
	_	motion synthesis; facial animations							
Prerequisites	Recommended								
1	MA-INF 2111		ns of Gra	phics					
	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	Written exam				(gra	ded)			
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)			
Forms of media					•				
	• Dietmar Jac	kel, Stephan	Neunreit	her, Fried	drich Wagner:				
	Methoden der Computeranimation, Springer 2006								
T*4	• Rick Parent: Computer Animation: Algorithms and								
Literature	Techniques, M	lorgan Kaufn	nan Publ	ishers 200)2				
	• Frederic I. P	arke , Keith	Waters:	Compute	r Facial Anima	tion.			
	A K Peters, L	td. 1996							

Module MA-INF 2203	Selected To	pics in Sign	nal Pro	ocessing				
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every	year				
Module	apl. Prof. Dr.	Frank Kurth	1					
coordinator								
Lecturer(s)	apl. Prof. Dr.	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu		Option					
Technical skills	Learning adva	Learning advanced as well as state of the art topics and						
	techniques in digital signal processing. Study examples from the							
	field of digital	field of digital audio signal processing with a focus on music						
	audio. Develo	audio. Develop skills for analysing audio signals and designing						
	audio features	audio features for selected application scenarios. Mathematical						
	_	modelling of signal processing problems in practical applications.						
	~	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.							
Contents		Advanced techniques for filter design, design and extraction of						
		_	_		ent DSP algorit	hms,		
	general concep			-				
	=		_		ns, for example			
			is, signa	l compres	sion, denoising,			
	source separat	ion.						
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		
	T = face-to-fa	ce teaching; S	S = inde	pendent s	study			
Exam achievements	Written exam				(gra	ided)		
Study achievements	Successful exe	rcise participa	ation		(not gra	ided)		
Forms of media								
	• Lecture scrip	ot and selecte	d resear	ch publica	ations			
	• Hayes: Statistical Digital Signal Processing and Modelling,							
	John Wiley, 1996							
Literature		nolakis: Digit	al Signa	l Processi	ing, Prentice Ha	all,		
	1996							
	• Klapuri, Davy: Signal Processing, Methods for Music							
	Transcription, Springer, 2006							

Module MA-INF 2204	Rendering Techniq	ues I					
Workload	Credit points Duratio	n Freque	ncy				
180 h	6 CP 1 seme						
Module	Prof. Dr. Reinhard Kle						
coordinator							
Lecturer(s)	Prof. Dr. Reinhard Kle	ein					
Classification	Programme	Mode	Semes	ter			
Classification	M. Sc. Computer Scien	nce Optiona	$1 \mid 2.$				
Technical skills	and knowledge of techr of photorealistic image for the simulation of lig	Analytical formulation of problems related to image synthesis and knowledge of techniques and algorithms for the generation of photorealistic image data. Knowledge of the major algorithms for the simulation of light distributions in 3D-scences and volume data sets. Self-dependent implementation of the basic algorithms					
Soft skills	solution of practical pr presentation of solution	Analytical problem description, creativity, self-dependent solution of practical problems in the area of rendering, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management					
Contents	Topics among others will be: models for the description of optical material properties and light sources; transport, volume visualization and rendering equation; algorithms and techniques for the solution of the volume visualization and rendering equation; advanced methods for photorealistic image generation in real-time applications like 3D games. In addition, results from						
Prerequisites	state of the art research Recommended:	n win be pres	ciiica.				
Trorequisites	Algorithms and data st multidimensional analy stochastics and statisti- linear algebra, C++	rsis und linear	algebra,	basic knowledg	ge in		
	Teaching format	Group size	h/week	Workload[h]	CP		
Format	Lecture Exercises	. C . 1	2 2	30 T / 45 S 30 T / 75 S	2.5 3.5		
	T = face-to-face teachi	ng; S = nnep	pendent st		1 1\		
Exam achievements	Oral exam	tiainatian		,-	$\frac{\text{ded}}{\text{ded}}$		
Study achievements Forms of media	Successful exercise part	acipation		(not gra	uea)		
rorius oi media	• L. Szirmay-Kalos: Monte-Carlo Methods in Global Illumination, Institute of Computer Graphics, Vienna University of Technology, Vienna. URL: citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html,						
Literature	 1999/ P. Dutre, K. Bala, P. Bekaert: Advanced Global Illumination, 2nd ed., B&T, 2006 M. Pharr, G. Humphreys: Physically Based Rendering, Elsevier, 2004 						
	• J. Kautz, J. Lehtinen Transfer: Theory and I		_				

Module	Geometry I	Processing	Ι					
MA-INF 2205								
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semeste	every y	ear				
Module	Prof. Dr. Rein	nhard Klein						
coordinator								
Lecturer(s)	Prof. Dr. Rein	Prof. Dr. Reinhard Klein						
Classification	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu		Optiona					
Technical skills	Analytical form	analytical formulation of problems related to geometry						
	processing and	_	-		_			
	optimize, proc					ing		
	of techniques t	_						
	digital models of real objects and to implement current geometry processing algorithms.							
Soft skills	Analytical problem description, creativity, self-dependent solution of practical problems in the area of mesh processing							
	_	_				5,		
	presentation o		_	-	,			
	self-dependent literature research, collaboration abilities							
<u> </u>	self-manageme		- M-41 J	_ f 41				
Contents	Topics among other will be: Methods for the generation of							
	polygonal meshes (Laser scanning, registration and integration of single mesh parts, etc.), Point based representations,							
	Reconstruction techniques, Efficient mesh data structures and							
	mesh compression, Optimization: denoising and smoothing,							
	Mesh decimation and refinement, Hierarchical representations:							
	coarse-to-fine							
	addition result		,					
Prerequisites	Recommended		01 0110 011	7 1 00 001 011	Will be present			
1 ToToquistos	Algorithms an		tures, bas	ic knowle	dge on			
	multidimension				_	ge in		
	stochastics and							
	linear algebra,			v				
	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	Oral exam	0,	1			ded)		
Study achievements	Successful exe	rcise partici	oation		(not gra			
Forms of media					, ,			
	• R. Scopigno	, C. Anduja	, M. Goes	ele, H. Le	ensch: 3D Data	ì		
	Acquistion, Eurographics Tutorial, 2002							
	• E. Grinspun, M. Desbrun (organizers): Discrete Differential							
Literature	_	Applied In	roduction	, Siggrapl	n Course Notes	5,		
	2006							
	· · · · · · · · · · · · · · · · · · ·			_	Based on Triai	ngle		
	Meshes, Siggra	• M. Botsch, M. Pauly: Geometric Modeling Based on Triangle Meshes, Siggraph Course Notes, 2006						

Module MA-INF 2206	Seminar Vision						
Workload	Credit points	Duration	Freque	ncv			
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	l 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 correspo	nding area	, •			
Contents	Current confer	rence and jo	ırnal pape	ers.			
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	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 2207	Seminar Graphics						
Workload	Credit points	Duration		Freque	ncy		
120 h	4 CP	1 semes	ter	every s	emester		
Module	Prof. Dr. Reir	Prof. Dr. Reinhard Klein					
coordinator							
Lecturer(s)	Prof. Dr. Rein	nhard Klei	n				
Classification	Programme			Mode	Semest	ter	
Classification	M. Sc. Compu	iter Scienc	e	Optiona	l 2. or 3	3.	
Technical skills	Ability to und	erstand ne	ew r	esearch 1	esults pre	esented in origi	inal
		scientific papers.					
Soft skills		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	_	,		ensional	analysis and li	near
	algebra, basic	numerical	met	thods)			
	Basic knowled	ge in Com	put	er Graph	nics		
Format	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 teachin	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en re	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 se	mester			
Module	apl. Prof. Dr.	Frank Kurtl	1				
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.			
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							

Module MA-INF 2209	Advanced T	opics i	n Comp	uter Grapl	nics I			
Workload 270 h	Credit points 9 CP	Duration 1 semes		uency				
Module coordinator	Prof. Dr. Reinha		ter every	year				
Lecturer(s)	Prof. Dr. Reinha	rd Klein						
Classification	Programme M. Sc. Computer	r Science	Mode Optional	Semester 2. or 3.				
Technical skills	rendering. Know analyze and store major algorithms	Analytical formulation of problems related to geometry processing and rendering. Knowledge of techniques and algorithms to optimize, process, analyze and store geometry and reflectance data as well as knowledge of the major algorithms for the simulation of light distributions in 3D-scences and volume data sets. Self-dependent implementation of the basic algorithms.						
Soft skills	Based on the kno	Based on the knowledge and skills acquired students should be able to						
Contents	processing and re identify the maprocessing or ren discuss problem researchers from processing or ren researchers from and should have results, flexibility to communicate	 read and judge current scientific literature in the area of geometry processing and rendering identify the major literature concerning a given problem in geometry processing or rendering and gain an overview of the current state of the art discuss problems concerning geometry processing or rendering with researchers from different application fields present and propose different solutions and work in a team to solve a mesh processing or rendering problem and should have acquired key-competences like motivation to deliver results, flexibility, scientific integrity, ability to adapt to changes and ability 						
	Topics among other will be: • methods for the generation of polygonal meshes from point clouds • efficient mesh data structures and mesh compression • mesh optimization techniques: denoising, smoothing, decimation, refinement • mesh editing techniques • optical material properties and light sources • light transport and rendering equation • algorithms and techniques for the solution of the rendering equation • advanced methods for photorealistic image generation.							
Prerequisites		in compu	ter graphics	, data structure	s, multidimensiona americal linear alge			
	Teaching forma	at	Group s	size h/week	Workload[h]	CP		
Format	Lecture Exercises			4 2	60 T / 105 S 30 T / 75 S	5.5 3.5		
	T = face-to-face	teaching.	S = independence 1	ı	, , , , ,	-		
Exam achievements	Oral presentation			J	(gra	ded)		
Study achievements			*		,-			
Forms of media Literature	 Successful exercise participation (not graded) M. Botsch, L. Kobbelt, M. Pauly, P. Alliez, B. Levy, Polygon Mesh Processing, A K Peters (7. Oktober 2010) M. Gross, HP. Pfister, Point-Based Graphics, Morgan Kaufmann (21. Juni 2007) R. Scopigno, C. Andujar, M. Goesele, H. Lensch: 3D Data Acquistion, Eurographics Tutorial, 2002 E. Grinspun, M. Desbrun (organizers): Discrete Differential Geometry: An Applied Introduction, Siggraph Course Notes, 2006 L. Szirmay-Kalos: Monte-Carlo Methods in Global Illumination, Institute of Computer Graphics, Vienna University of Technology, Vienna. URL: citeseer.ist.psu.edu/szirmay-kalos00montecarlo.html, 1999/ P. Dutre, K. Bala, P. Bekaert: Advanced Global Illumination, 2nd ed., B&T, 2006 M. Pharr, G. Humphreys: Physically Based Rendering, Elsevier, 2nd revised edition. (26. August 2010) 							

Module MA-INF 2210	Seminar Computer Animation						
Workload	Credit points	Duration	ı	Freque	ncy		
120 h	4 CP	1 semes					
Module	Prof. Dr. Andreas Weber						
coordinator							
Lecturer(s)	Prof. Dr. And	lreas Web	er				
Classification	Programme			Mode	Semest	ter	
Ciassification	M. Sc. Compu	iter Scienc	ce	Optional	1 2.		
Technical skills	Ability to und	erstand n	ew	research 1	esults pre	esented in original	inal
	scientific pape	scientific papers.					
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the					
	framework of	the corres	pon	ding area	, ·		
Contents	Current confer	rence and	jou	rnal pape	ers.		
Prerequisites	Recommended	:					
	At least 1 of t	he followi	ng:				
	MA-INF 2202	– Compu	ter	Animatic	n		
	MA-INF 2311	– Lab Co	mp	uter Anir	nation		
To 4	Teaching forms	at	\mathbf{Gr}	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	ion, writt	en 1	report		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature							

Module	Pattern Matchi	_	Machin	ıe Learı	ning for Aud	lio	
MA-INF 2212	Signal Processi	ng					
Workload	Credit points Dur	ration	Frequer	ncy			
180 h	6 CP 1 s	semester	mester every year				
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 S	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 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 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	Computation	onal Photo	graphy					
Workload	Credit points	Duration	Frequer	ncy				
180 h	6 CP	1 semester	every y	-				
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	_		image sen	sors. Sign	nal processing a	and		
	inverse problei	ms in imagin	g. Color s	paces and	d 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 Dig	gital Mate	rial App	earance	9	
Workload	Credit points	Duration	Frequen	ıcy		
120 h	4 CP	1 semester	every ye	ear		
Module	Prof. Dr. Mat	thias Hullin	-			
coordinator						
Lecturer(s)	Prof. Dr. Mat	thias 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	Lab Visual Computing						
MA-INF 2216							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	every	every year			
Module	Jun-Prof. Dr.	Jun-Prof. Dr. Angela Yao					
coordinator							
Lecturer(s)	Jun-Prof. Dr.	Jun-Prof. Dr. Angela Yao					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Option	al 1-4.			
Technical skills	The students	will carry ou	t a pract	ical task ((project) in the		
	context of computer vision, including test and documentation of						
	the implement	the implemented software/system.					
Soft skills	Ability to prop	Ability to properly present and defend design decisions, to					
	prepare readal	ble documen	tation of	software;	skills in		
	constructively	collaboratin	g with ot	thers in sr	nall teams over	a	
	longer period	of time; abili	ty to clas	ssify ones	own results into	o the	
	state-of-the-ar	t of the resp	. area				
Contents		•			s and application	ns.	
	You will get a				- 0		
			_	-	s. At the end of	the	
	semester, you	will present	the meth	od, give ϵ	a short		
			a repor	t describi	ng the method a	and	
	experimental of	outcomes.					
Prerequisites	none						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Tormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	ependent s	study		
Exam achievements	Oral presentat	tion, 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	competing methods, discussion in groups.						
Contents	This course for	This course focuses on cutting-edge Deep Learning techniques						
	for computer g	for computer graphics. After a brief review of CNNs the focus						
	will be laid on	autoencode	ers, generat	tive mode	els 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 text, supplemental readings will be given in class.							

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	Prof. Dr. Jürgen Gall							
Classification	Programme	ogramme		Semest	ter				
Classification	M. Sc. Compu	Optional	l 2-4.						
Technical skills	Students will l	Students 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-	a 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	Seminar Visualization and Medical Image Analysis							
Workload	Credit points	Duration	Frequer	ncy					
120 h	4 CP								
Module	Prof. Dr. Tho	mas Schult	Z						
coordinator									
Lecturer(s)	Prof. Dr. Thomas Schultz								
Classification	Programme		Mode	Semest	ter				
Classification	M. Sc. Compu	Optional	$\lfloor \ $						
Technical skills	Ability to understand new research results presented in original scientific papers.								
Soft skills	Ability to pres	sent and to	critically di	scuss scie	entific results in	1 the			
	context of the current state of the art. Ability to perform an								
	independent se	independent search for relevant scientific literature.							
Contents	Current confer	Current conference and journal papers							
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	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	mplemented 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 Vi	sual Com	puting					
Workload	Credit points	Duration	Frequer	ncv				
120 h	4 CP	1 semeste	_	•				
Module	Jun-Prof. Dr.	Angela Yac						
coordinator		_						
Lecturer(s)	Jun-Prof. Dr. Angela Yao							
Classification	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	Optional	2. or 3	3.				
Technical skills	Ability to und	erstand new	research r	esults pre	esented in origina	al		
	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	Current conference and journal papers						
Prerequisites	Required:							
	At least 1 of the	he following	:					
	MA-INF 2201	- Compute	r Vision					
	MA-INF 2217	- Advanced	Deep Lea	rning for	Graphics			
	MA-INF 2313	– Deep Lea	rning for V	isual Rec	cognition			
	MA-INF 4315	– Probabili	stic Graph	ical Mode	els			
Format	Teaching forms	at G	roup size	h/week	Workload[h]	$\overline{\mathbf{CP}}$		
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		(grade	ed)		
Study achievements					(not grade	ed)		
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	omas Schultz,	Prof. D	r. Reinha	rd Klein				
Classification	Programme		Mode	Seme	ster				
Classification	M. Sc. Compu	iter Science	Option	al 1-4.					
Technical skills	Ability to desi	Ability to design, implement, and make proper use of systems							
	for visual data	for visual data analysis. Knowledge of algorithms and							
	techniques for the visualization of multi-dimensional data,								
	graphs, as wel	l as scalar, ve	ctor, an	d tensor f	ields.				
Soft skills		Productive work in small teams, self-dependent solution of							
	practical problems in the area of visual data analysis, critical								
	reflection on visualization design, presentation of solution								
	_	strategies and implementations, self management							
Contents	_	This class provides a broad overview of principles and							
	algorithms for	data analysis	via inte	eractive v	isualization.				
	Specific topics	include perce	eptual p	rinciples,	luminance and				
	· ·	-			gration of visual				
					arning, as well a	as			
	specific algorit		_						
				-	tion, graphs, dir	rect			
	and indirect v								
	visualization,		sor field	visualiza	tion.				
Prerequisites	Recommended								
					nowledge in line				
	_				programming.				
	Teaching form	at Gro	up size	h/week	Workload[h]	СР			
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, Data Visualization: Principles and Practice. CRC Press, Second Edition, 2015								
Literature	M. Ward et al., Interactive Data Visualization: Foundations, Techniques, and Applications. CRC Press, 2010								
	T. Munzner, V 2015	Visualization A	Analysis	and Desi	gn, A K Peters	,			

Module MA-INF 2302	Physics-based Modelling								
Workload	Credit points	Duration	Freque	ncv					
180 h	6 CP	1 semester							
Module	Prof. Dr. Andreas Weber								
coordinator									
Lecturer(s)	Prof. Dr. Andreas Weber								
· · ·	Programme		Mode	Semest	ter				
Classification	M. Sc. Compu	iter Science	Optional	1 3.					
Technical skills	Students learn	Students learn the fundamental techniques of physics-based							
	modelling for o	modelling for computer graphics and computer animation. The							
	students shall	tudents shall be able to choose appropriate mathematical							
	models. Know	nodels. Knowing the algorithmic techniques and algorithmic							
	issues, they sh	ssues, they shall be able to come up with software solutions for							
	specific proble	specific problems.							
Soft skills	Social compete	Social competences (work in groups), communicative skills							
	(written and o	(written and oral presentation)							
Contents	Initial value pr	roblems; par	ticle simul	ation; rigi	id body simula	tion;			
	multi-body-sys	stems; collisi	on detecti	on; collisi	ons response;	cloth			
	modelling; hai	r modelling;	physics-ba	ased moti	on synthesis				
Prerequisites	Recommended	:							
	MA-INF 2111	- Foundation	ns of Graj	phics					
	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 exer	rcise particip	oation		(not gra	ded)			
Forms of media									
	• Dietmar Jackel, Stephan Neunreither, Friedrich Wagner:								
Literature	Methoden der								
Diterature	• David M. Bo								
	Advanced co	ourse notes o	n physics-	based mo	delling				

Module	Rendering Techniques II							
MA-INF 2304	recirecting	rcennique	,5 11					
Workload	Credit points	Duration	Freque	ncv				
180 h	6 CP	1 semeste	_	-				
Module	Prof. Dr. Reir		-	-				
coordinator	1101. 21. 1001	inara mioni						
Lecturer(s)	Prof. Dr. Reir	hard Klein						
Lecturer (b)	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	ıter Science						
Technical skills	Analytical form		_		image based			
recifficat skins	· ·		-		_	of		
	_	rendering and knowledge of advanced techniques in the field of rendering. Knowledge of methods and models for the acquisition						
	_	and description of light sources and optical material properties						
	_			-	dge of methods			
	models for the acquisition and description of image based							
		-		-	. Self-depender	$_{ m it}$		
	implementatio	_			1			
Soft skills	Analytical pro				f-dependent			
		solution of practical problems in the area of image based						
	rendering and	digital pho	tography, p	resentatio	on of solution			
	strategies and	implement	ations, self-	dependen	t literature			
	research, colla	boration ab	ilities, self-	managem	ent			
Contents	Topics among	Topics among others will be: advanced material acquisition and						
	modelling tech	niques; alg	orithms and	d techniqu	ues of image ba	ased		
	rendering; digi	tal photogr	aphy for in	nage base	d scene modell	ing		
	and rendering;	computati	onal photog	graphy				
Prerequisites	Recommended	:						
	Algorithms an				_			
		_			basic knowledg	ge in		
	stochastics and		numerical	analysis a	and numerical			
	linear algebra,							
	Teaching forma	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				(gra	ded)		
Study achievements	Successful exe	rcise partici	pation		(not gra	ded)		
Forms of media								
			, –	,	alistic Materia	ls in		
	Computer Graphics, Siggraph Course Notes, 2005							
	• P. Debevec, E. Reinhard (organizers): High-Dynamic-Range Imaging: Theory and Applications, Siggraph Course Notes, 2006							
Literature						2006		
	• N. Hoffman	` - ,			tenectance for			
	Games, Siggra	_			tational			
l	• R. Raskar, J		. – ,	_	tational			
	Photography, Siggraph Course Notes, 2006							

Module	Geometry I	Geometry Processing II							
MA-INF 2305									
Workload	Credit points	Duration	n	Frequer	ncy				
180 h	6 CP	1 semes	ster	every y	ear				
Module	Prof. Dr. Reir	hard Kle	in	l					
coordinator									
Lecturer(s)	Prof. Dr. Reir	nhard Kle	in						
CI 10 II	Programme			Mode	Semest	ter			
Classification	M. Sc. Compu	iter Scien	ce	Optional	3.				
Technical skills	Analytical form	mulation of	of pr	oblems r	elated to	geometry			
	processing, sha	ape analy	sis a	nd shape	retrieval	as well as			
	knowledge of a	advanced	algo	rithms a	nd technic	ques from thes	e		
	fields. Self-dependent implementation of the algorithms.								
Soft skills	Analytical problem description, creativity, self-dependent								
	solution of pra	ctical pro	blen	ns in the	area of in	mage based			
	rendering and	digital pl	notog	graphy, p	resentatio	on of solution			
	strategies and	_			_				
	research, collaboration abilities, self-management								
Contents	This class is focussed on advanced topics in the field of geometry								
	processing. St		_			-			
	in the area of	shape ana	alysis	s and sha	pe retriev	val. Topics am	ong		
	others will be								
	Parameteriza	ation of s	urfac	ces					
	• Shape segme	entation a	nd s	hape sim	ilarity				
	• Shape classif					eval			
	• Shape spaces	s and stat	istic	al shape	analysis				
Prerequisites	Recommended	:							
	Algorithms an					_			
	multidimension	_			_		ge in		
	stochastics and		s, nu	ımerical	analysis a	and numerical			
	linear algebra,					I			
	Teaching forms	at	Gro	oup size	h/week		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	= indep	endent st				
Exam achievements	Oral exam						ded)		
Study achievements	Successful exe	rcise part	icipa	tion		(not gra	ded)		
Forms of media									
	• T. Funkhous			-					
	Analysis of 3D-Models, Siggraph Course Notes, 2004								
	• L. Dryden, K.V. Mardia, Statistical Shape Analysis, John								
Literature	Wiley & Sons,		/ 1.			1 4 1			
			,	,		nd Analysis of	1		
	_ `	_				Engineering and	1		
	Technology), Birkhäuser Boston, 2006								

Module	Virtual Rea	lity							
MA-INF 2306									
Workload	Credit points	Duration	Frequer	ıcy					
180 h	6 CP	CP 1 semester every year							
Module	Prof. Dr. Rein	nhard Klein							
coordinator									
Lecturer(s)	Prof. Dr. Rein	nhard Klein							
C1 10 11	Programme		Mode	Semes	ter				
Classification	M. Sc. Compu	iter Science	Optional	l 3.					
Technical skills	Basic knowled	ge of hard- a	nd softwa	re compo	nents of currer	nt			
	VR-Systems, 1	- Broad knowle	edge of tra	acking-, c	ollision detecti	on-			
	and real-time	rendering alg	gorithms, 1	knowledge	e of methods t	О			
	integrate hapt	ic and sound	, knowled	ge of GP	U programmin	g			
	with emphasis	on special e	ffect gener	ration, ab	ility to implen	nent			
	components of	a VR-Syste	m						
Soft skills	Analytical pro	blem descrip	tion, crea	tivity, sel	f-dependent				
	solution of pra	solution of practical problems in the area of Virtual Reality,							
	presentation o	f solution str	ategies an	ıd implen	nentations,				
	self-dependent	self-dependent literature research, collaboration abilities,							
	self-manageme	self-management							
Contents	Scene Graphs,	Scene Graphs, Stereo Seeing (HW, SW), Tracking (HW, SW),							
	Acceleration T	Acceleration Techniques (LOD; Culling), Collision detection,							
	Haptics, Sound	Haptics, Sound, Special effects (GPU-Programming)							
Prerequisites	Recommended	:							
	Mathematical	_	,		-				
	algebra, found			,	good knowledge	e of			
	the foundation			S					
	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	Oral exam				(gra	ided)			
Study achievements	Successful exe	rcise particip	ation		(not gra	>			
Forms of media									
	• K. Stanney	(ed.): Handb	ook of Vi	rtual Env	ironments.				
	Lawrence Erlb	aum Associa	ites, 2002						
	• W. Sherman	, A. Craig: 1	Jnderstan	ding Virt	ual Reality.				
T*4	Morgan Kaufman, 2002								
Literature	• D. Pape: Co	mmodity-Ba	sed Proje	ction VR.	, Siggraph Cou	ırse			
	Notes, 2006								
	 N. Tatarchuk (organizer): Advanced Real-Time Rendering Graphics and Games, Siggraph Course Notes, 2006 								

Module	Lab Vision							
MA-INF 2307								
Workload	Credit points	Duration		Freque	-			
270 h	9 CP	1 sem	ester	every	semester			
Module	Prof. Dr. Jürg	gen Gall						
coordinator								
Lecturer(s)	Prof. Dr. Jürg	Prof. Dr. Jürgen Gall						
Classification	Programme			Mode	Seme	ster		
Classification	M. Sc. Computer Science		nce	Option	al 2. or	3.		
Technical skills	The students	will carr	y out	a pract	ical task ((project) in the		
	context of RG	B-D can	neras.					
Soft skills	Ability to prop	perly pre	esent a	and defe	end design	n decisions, to		
		prepare readable documentation of software; skills in						
	constructively	collabor	ating	with of	hers in sr	nall teams over	a	
	longer period	of time;	ability	y to clas	ssify ones	own results into	the the	
	state-of-the-ar	t of the	resp.	area	· ·			
Contents	RGBD camera	as: resea	rch to	pics an	d applicat	ions		
Prerequisites	Required:							
	MA-INF 2201	- Comp	uter V	Vision				
	Good C++ pr	ogramm	ing sk	ills				
To the second se	Teaching forms	at	Grou	ıp size	h/week	Workload[h]	CP	
Format	Lab			8	4	60 T / 210 S	9	
	T = face-to-fa	ce teach	ing; S	= inde	pendent s	study		
Exam achievements	Oral presentat	ion, wri	tten re	eport		(gra	ded)	
Study achievements						(not gra	ded)	
Forms of media								
	A. Fossati, J. Gall, H. Grabner, X. Ren, K. Konolige. Consumer							
Literature	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	Prof. Dr. Reinhard Klein						
CI 10 II	Programme			Iode	Semes	ster		
Classification	M. Sc. Computer Science			ptional	3.			
Technical skills	The students v	The students will carry out a practical task (project) in the						
	context of geor	metry prod	cessin	ıg, rende	ering, sc	ientific visualiza	ation	
	or human com	or 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 semester every year							
Module	apl. Prof. Dr.	Frank Ku	rth					
coordinator								
Lecturer(s)	apl. Prof. Dr.	apl. Prof. Dr. Frank Kurth, Prof. Dr. Michael Clausen						
Classification	Programme		Mode	Seme	Semester			
Classification	M. Sc. Compu	iter Scienc	e Option	al 3.	3.			
Technical skills	The students v	will carry o	out a pract	ical task	(project) in the			
	context of aud	io and mu	sic process	ing, includ	ding test and			
	documentation	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; 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								

270 h Module coordinator Lecturer(s) Classification Technical skills Soft skills	world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometr based acquisitio select and appromputer graph incorporate based	er Science s of geomet: and design s of shape s chape retriev oncepts of st cations ric and radio on systems oly light sou uics applicat	Mode Optional y and digitand implementation al applicate attistical shometric cal rece and options	Semester 3. tal appearament novel a on and shape ions tape analysis	e similarity to not and shape space	rare ovel ces to	
270 h Module coordinator Lecturer(s) Classification Technical skills Soft skills	9 CP Prof. Dr. Reinh Programme M. Sc. Compute • apply method world problems in these areas • apply method problems • design novel s • apply basic coreal world appli • apply geometr based acquisitio • select and appropriate based • incorporate based	1 semester hard Klein er Science s of geometrand design s of shape s chape retrievencepts of structure and radion systems oly light sources applicat	Mode Optional y and digitand implementation al applicate attistical shometric cal rece and options	Semester 3. tal appearament novel a on and shape ions tape analysis	pplication softweet similarity to not and shape space or think to came.	rare ovel ces to	
Module coordinator Lecturer(s) Classification Technical skills Soft skills Contents	Prof. Dr. Reinh Programme M. Sc. Compute • apply method world problems in these areas • apply method problems • design novel s • apply basic coreal world appli • apply geometr based acquisitio • select and appropriate based • incorporate based	er Science s of geomet: and design s of shape s chape retrievencepts of st cations ric and radio n systems oly light sou nics applicat	Mode Optional y and digitand implementation al applicate attistical shometric cal rece and options	Semester 3. tal appeararment novel a on and shape ions tape analysis ibration algorithms.	pplication softweet similarity to not and shape space or think to came.	rare ovel ces to	
Contents	Prof. Dr. Reinh Programme M. Sc. Compute apply method world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometr based acquisitio select and appropriate based incorporate based	er Science s of geomet: and design s of shape s chape retriev oncepts of st cations ric and radio on systems oly light sou uics applicat	Optional by and digitand implementation al applicate attistical shometric cal by conserving and options	3. tal appearar ment novel a on and shape ions ape analysis ibration algo	pplication softweet similarity to not and shape space or think to came.	rare ovel ces to	
Lecturer(s) Classification Technical skills Soft skills Contents	Programme M. Sc. Compute apply method world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometr based acquisitio select and appromputer graph incorporate bases	er Science s of geometrand design s of shape s chape retrieve oncepts of st cations ric and radio on systems oly light sou nics applicat	Optional by and digitand implementation al applicate attistical shometric cal by conserving and options	3. tal appearar ment novel a on and shape ions ape analysis ibration algo	pplication softweet similarity to not and shape space or think to came.	eare ovel ces to	
Classification Technical skills Soft skills Contents	Programme M. Sc. Compute apply method world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometr based acquisitio select and appromputer graph incorporate bases	er Science s of geometrand design s of shape s chape retrieve oncepts of st cations ric and radio on systems oly light sou nics applicat	Optional by and digitand implementation al applicate attistical shometric cal by conserving and options	3. tal appearar ment novel a on and shape ions ape analysis ibration algo	pplication softweet similarity to not and shape space or think to came.	eare ovel	
Technical skills Soft skills Contents	M. Sc. Computer apply method world problems in these areas apply method problems design novel s apply basic correal world appli apply geometric based acquisitio select and appropriate based incorporate based.	s of geometrand design s of shape s chape retrievely oncepts of st cations ric and radio on systems only light sounces applicat	Optional by and digitand implementation al applicate attistical shometric cal by conserving and options	3. tal appearar ment novel a on and shape ions ape analysis ibration algo	pplication softweet similarity to not and shape space or think to came.	eare ovel	
Technical skills Soft skills Contents	 apply method world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometric based acquisitio select and appropriate based incorporate based 	s of geometrand design s of shape s chape retrievely oncepts of st cations ric and radio on systems only light sounces applicat	y and digitand implest egmentation al applicate attistical shometric calurce and opons	tal appearar ment novel a on and shape ions ape analysis	pplication softweet similarity to not and shape space or think to came.	eare ovel	
Soft skills Contents	world problems in these areas apply method problems design novel s apply basic coreal world appli apply geometr based acquisitio select and appromputer graph incorporate based	and design s of shape s chape retrieved the second second radio on systems on systems on specific spec	and impler egmentatical al applicatatistical shometric cal cree and opons	ment novel a on and shape ions lape analysis ibration algo	pplication softweet similarity to not and shape space or this to came.	eare ovel	
Contents	Analytical prob	 apply methods of shape segmentation and shape similarity to novel problems design novel shape retrieval applications apply basic concepts of statistical shape analysis and shape spaces to real world applications apply geometric and radiometric calibration algorithms to camera based acquisition systems select and apply light source and optical material models for computer graphics applications incorporate basic image based algorithms into rendering applications 					
	Analytical problem description, creativity, self-dependent solution of practical problems, presentation of solution strategies and implementations, self-dependent literature research, collaboration abilities, self-management. This class is focused on advanced topics in the field of geometry, and						
	This class is focused on advanced topics in the field of geometry and digital appearance processing. Students will get familiar with recent developments in the area of shape analysis, shape retrieval, material acquisition and modeling techniques. Topics among others will be						
	 Parameterization of surfaces Shape segmentation and shape similarity Shape classification and content based retrieval Shape spaces and statistical shape analysis Optical material acquisition and modelling techniques Algorithms and techniques of image based rendering Digital photography for image based scene modelling and rendering Basic computational photography 						
Prerequisites	none						
	Teaching forma	at	Group size	h/week	Workload[h]	CP	
		60 T / 105 S 30 T / 75 S	5.5 3.5				
	Oral exam	. ,	acpo	staaj	(ors	aded)	
	Successful exerc	rise participe	tion		(not gra		
Forms of media	Successiui exerc	no participa			(1100 810	iaca,	
Literature							

Module	Lab Compu	Lab Computer Animation						
MA-INF 2311								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	at least every year					
Module	Prof. Dr. And	reas Weber	'					
coordinator								
Lecturer(s)	Prof. Dr. And	Prof. Dr. Andreas Weber						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	Optiona	al 3.					
Technical skills	The students v	will carry ou	t a pract	ical task ((project) in the			
	context of com	nputer anima	ation, inc	luding tes	st and			
	documentation	of the imp	emented	software/	system.			
Soft skills	Ability to prop	perly presen	and defe	end design	n decisions, to			
		prepare readable documentation of software; skills in						
		constructively collaborating with others in small teams over a						
	O 1	longer period of time; ability to classify ones own results into the						
	state-of-the-art of the resp. area							
Contents		-	se to cur	rent resea	rch in the area	of		
	computer anin	nation.						
Prerequisites	Recommended							
	At least 1 of the	he following						
	MA-INF 2202	- Computer	Animati	on				
	MA-INF 2302	- Physics-b	ased Mod	lelling				
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								
Literature								

Module	Image Acqu	Image Acquisition and Analysis in Neuroscience								
MA-INF 2312										
Workload	Credit points	Duration	Frequer	ıcy						
180 h	6 CP	6 CP 1 semester at least every 2 years								
Module	Prof. Dr. Tho	mas Schultz	-1							
coordinator										
Lecturer(s)	Prof. Dr. Tho	Prof. Dr. Thomas Schultz								
Cl:64:	Programme		Mode	Semes	ter					
Classification	M. Sc. Compu	iter Science	Optional	l 1-4.						
Technical skills	Students will	learn about i	mage acqu	uisition a	nd analysis					
	pipelines which	h are used in	neuroscie	ence. The	y will understa	and				
	algorithms for	image recon	struction,	artifact ı	removal, image					
	registration ar	nd segmentat	ion, as we	ll as relev	vant statistical	and				
	machine learn	ing technique	s. A part	icular foc	us will be on d	lata				
	from Magnetic	c Resonance	maging a	nd on ma	thematical mo	dels				
	for functional	and diffusion	MRI dat	a.						
Soft skills	Productive wo	ork in small t	eams, self	-depende	nt solution of					
		practical problems in the area of biomedical image processing,								
	presentation of solution strategies and implementations, self									
	management, critical reflection of conclusions drawn from									
	complex experimental data.									
Contents	This course co	This course covers the full image formation and analysis pipeline								
	that is typical	ly used in bio	medical s	studies, fr	om image					
	acquisition to	image proces	sing and	statistical	l analysis.					
Prerequisites	Recommended	l :								
	Mathematical	background	(calculus,	linear alg	gebra, statistic	s);				
	imperative pro	ogramming.								
	Teaching forms	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-face teaching; S = independent study									
Exam achievements	Oral exam					ded)				
Study achievements	Successful exe	rcise particip	ation		(not gra					
Forms of media					, ,					
	• B. Preim, C. Botha: Visual Computing for Medicine: Theory,									
	Algorithms, and Applications. Morgan Kaufmann, 2014									
	• R.A. Poldrack, J.A. Mumford, T.E. Nichols: Handbook of									
Literature					niversity Press					
	2011		-	J	Ü					
	• D.K. Jones:	Diffusion M	RI: Theor	y, Method	d, and					
	• D.K. Jones: Diffusion MRI: Theory, Method, and Applications, Oxford University Press, 2011									

Credit points Duration Frequency every year	Module	Deep Learning for Visual Recognition								
Module Prof. Dr. Reinhard Klein Prof. Dr. Michael Weinmann	MA-INF 2313	O 114	Chadit points Dunstion Programmy							
Prof. Dr. Reinhard Klein		=	1	_						
Classification Dr. Michael Weinmann										
Dr. Michael Weinmann		Prof. Dr. Reinnard Klein								
Programme Mode Semester		D W. 1 1777.								
M. Sc. Computer Science Optional 1-4.	Lecturer(s)		Veinmann	T = = =						
Students will be introduced to the theory of neural networks a study various applications in computer vision and other topics AI. Productive work in small teams, development and realization individual approaches and solutions, critical reflection of competing methods, discussion in groups. Deep learning has taken over the machine learning community by storm, with success both in research and commercially. De learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotic etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended	Classification	_				ter				
study various applications in computer vision and other topics AI. Productive work in small teams, development and realization individual approaches and solutions, critical reflection of competing methods, discussion in groups. Deep learning has taken over the machine learning community by storm, with success both in research and commercially. De learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotic etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications is visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Format				_						
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Productive work in small teams, development and realization individual approaches and solutions, critical reflection of competing methods, discussion in groups. Contents Deep learning has taken over the machine learning community by storm, with success both in research and commercially. De learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotic etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications is visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Lecture 2 30 T / 45 S		•	applications	in compu	ter vision	and other topi	cs in			
individual approaches and solutions, critical reflection of competing methods, discussion in groups. Deep learning has taken over the machine learning community by storm, with success both in research and commercially. De learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotic etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Lecture 2 30 T / 45 S										
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Contents Deep learning has taken over the machine learning community by storm, with success both in research and commercially. De learning is applicable over a range of fields such as computer vision, speech recognition, natural language processing, robotic etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Lecture 2 30 T / 45 S				,		eflection of				
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etc. This course will introduce the fundamentals of neural networks and then progress to state-of-the-art convolutional a recurrent neural networks as well as their use in applications visual recognition. Students will get a chance to learn how to implement and train their own network for visual recognition tasks such as object recognition, image segmentation and caption generation. Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Lecture 2 30 T / 45 S		learning is applicable over a range of fields such as computer								
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$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		recurrent neur	al networks	as well as	their use	in applications	s for			
		visual recognit	tion. Studen	ts will get	${\it a\ chance}$	to learn how t	О			
		implement and	d train their	own netw	ork for vis	sual recognition	n			
Prerequisites Recommended: Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size h/week Workload[h] Lecture 2 30 T / 45 S		tasks such as o	object recogn	nition, ima	ige segme	ntation and				
Students are recommended to have a basic knowledge in probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size $h/week$ Workload[h] Lecture 2 30 T / 45 S		caption genera	ation.							
probability and statistics and linear algebra as well as proficiency in programming (python or Matlab or C++). Teaching format Group size $h/week$ Workload[h] Format Lecture 2 30 T / 45 S	Prerequisites	Recommended	:							
		Students are r	ecommende	d to have a	a basic kn	owledge in				
		probability an	d statistics a	and linear	algebra a	s well as				
Format Lecture 2 30 T / 45 S		proficiency in	programmin	g (python	or Matla	b or $C++$).				
		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		Exercises			2	30 T / 75 S	3.5			
T = face-to-face teaching; $S = $ independent study		T — face-to-fa	ce teaching:	S = inder	endent st		1			
Exam achievements Oral exam (grad	Exam achievements		, ,		, , , , , , , , , , , , , , , , , , , ,		ded)			
Study achievements Successful exercise participation (not grade)			rcise partici	pation		,,,				
Forms of media		Successium CAC	reme partitel	7.01011		(1100 gra	acaj			
No required text. Supplemental readings will be provided in t	Torms or media	No required to	ext Supplem	ental reso	lings will	he provided in	the			
Literature lecture.	Literature	•	λί. Duppien	ionian ita(miga will	be provided in	0116			

Module MA-INF 2314	Image Proc	essing, Se	arch an	d Analy	rsis I			
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every	year				
Module	Prof. Dr. Chr.	istian Bauck	hage					
coordinator			J					
Lecturer(s)	Prof. Dr. Chr.	istian Bauck	hage					
CI 10 11	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.			
Technical skills	Upon complet		should	oe able to	ı			
	implement aimplement aimplement aimplement a	 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 design and implement their own algorithms for image processing 						
Soft skills	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 foundations / hardware aspects of digital photography mathematical representations of digital images coordinate systems and coordinate transformations Fourier transforms and convolutions low- band-, and high pass filtering mean- and Gaussian filtering median filtering and morphological operations efficient implementations of various kinds of filters interpolation methods artistic image effects image warping image morphing physiological foundations of color perception color spaces color manipulation 							
Prerequisites	none							
Format	Teaching formate Lecture Exercises $T = face-to-fa$		$\begin{array}{l} \textbf{oup size} \\ \\ \text{S} = \text{inde} \end{array}$	h/week 4 2 pendent s	Workload[h] 60 T / 105 S 30 T / 75 S study	5.5 3.5		
Exam achievements	Written exam					ded)		
Study achievements	Successful exe	rcise particir	ation		(not gra			
Forms of media	• lecture slides			online	(33 820	·)		
					are made availa	ble		
Literature	Gonzales andJähne, "Digi		_	_	essing"			

Module MA-INF 2315	Seminar Co	Seminar Computational Photography						
Workload	Credit points	Credit points Duration Frequency						
270 h	9 CP	1 semeste	r every	year				
Module	Prof. Dr. Mat	Prof. Dr. Matthias Hullin						
coordinator								
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthias Hullin						
Classification	Programme				ster			
Classification	M. Sc. Compu	M. Sc. Computer Science O		al 2. or	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	bungsteilna	hme		(not gra	ded)		
Forms of media								
Literature								

Module MA-INF 2316	Lab Digital	Material	Appear	rance				
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	rof. Dr. Matthias Hullin						
Classification	Programme	_		Seme	Semester			
Classification	M. Sc. Compu	M. Sc. Computer Science		al 2. or	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	bungsteilna	nme		(not gra	$\overline{\operatorname{ded}}$		
Forms of media								
Literature								

3 Information and Communication Management

MA-INF 31	06 L2E2	6 CP	Privacy in Ubiquitous Computing	70
MA-INF 32	01 L2E2	6 CP	Network Security	
MA-INF 32	02 L2E2	6 CP	Mobile Communication	72
MA-INF 32	07 L2E2	6 CP	Advanced Logic Programming	73
MA-INF 32	09 Sem2	4 CP	Seminar Selected Topics in Communication	
			Management	74
MA-INF 32	15 Sem2	4 CP	Seminar Selected Topics in Malware Analysis and	
			Computer/Network Security	75
MA-INF 32	16 Sem2	4 CP	Seminar Sensor Data Fusion	76
MA-INF 32	18 Sem2	4 CP	Seminar Model-Driven Software Engineering	77
MA-INF 32	19 Lab4	9 CP	Lab Model-Driven Software Engineering	78
MA-INF 32	22 L4E2	9 CP	eSecurity	7 9
MA-INF 32	27 Sem2	4 CP	Seminar Anonymity and Privacy on the Internet	80
MA-INF 32	29 Lab4	9 CP	Lab IT-Security	81
MA-INF 32	33 L2E2	6 CP	Advanced Sensor Data Fusion in Distributed Systems	82
MA-INF 32	34 Lab4	9 CP	Lab Mobile Sensing Systems	83
MA-INF 32	35 L2E2	6 CP	Usable Security and Privacy	84
MA-INF 32	36 L2E2	6 CP	IT Security	85
MA-INF 32	37 L2E2	6 CP	Array Signal and Multi-channel Processing	86
MA-INF 33	04 Lab4	9 CP	Lab Communication and Communicating Devices	87
MA-INF 33	05 Lab4	9 CP	Lab Information Systems	88
MA-INF 33	09 Lab4	9 CP	Lab Malware Analysis	89
MA-INF 33	10 L2E2	6 CP	Introduction to Sensor Data Fusion - Methods and	
			Applications	90
MA-INF 33	11 L4E2	9 CP	Topics in Applied Cryptography	91
MA-INF 33	12 Lab4	9 CP	Lab Sensor Data Fusion	92
MA-INF 33	17 Sem2	4 CP	Seminar Selected Topics in IT Security	93
MA-INF 33	18 Sem2	4 CP	Seminar Verification of Complex Systems	94
MA-INF 33	19 Lab4	9 CP	Lab Usable Security and Privacy	95
MA-INF 33	20 Lab4	9 CP	Lab Security in Distributed Systems	96
MA-INF 33	21 Sem2	4 CP	Seminar Usable Security and Privacy	97
MA-INF 33	22 L2E2	6 CP	Program Analysis and Binary Exploitation	98
MA-INF 33				
MA-INF 33	24 Lab4	9 CP	Lab Design of Usable Security Mechanisms	100

Module MA-INF 3106	Privacy in U	Ubiquito	us (Compu	ting		
Workload	Credit points	Duration		Frequer	ıcy		
180 h	6 CP	1 semest	er	every y	ear		
Module	JunProf. Dr.	Delphine	Chr	ristin			
coordinator							
Lecturer(s)	JunProf. Dr.	Delphine	Chr	ristin			
CI 10 II	Programme		I	Mode	Semes	ter	
Classification	M. Sc. Compu	iter Science	e (Optional	1-3.		
Technical skills	Students gain	knowledge	abo	out key o	concepts	of privacy	
	(including lega	al and econ	omi	ical aspe	cts) and	field of ubiquit	ous
	computing. The	hey are abl	e to	identify	threats	to privacy in g	iven
	application sce	enarios. Th	iey l	learn fur	ndamenta	l techniques to)
	protect users'	privacy. Re	elyiı	ng on th	is backgr	ound, they are	able
	to understand	and analys	ze c	utting-e	dge soluti	ions.	
Soft skills	Written and or	ral commu	nica	tive skil	ls, critica	l thinking and	
	problem solvin	ng skills, te	amv	work, an	d time m	anagement	
Contents	Introduction to			_	_	O, 2	
	threats, privac	ey-enhancir	ıg sy	ystems i	n selected	l scenarios, usa	able
	privacy						
Prerequisites	Recommended						
	MA-INF 3202	T			ion		
	Teaching forma	at (Gro	up 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	= indep	endent st	cudy	
Exam achievements	Oral exam					(gra	ided)
Study achievements	Successful exer	rcise partic	ipat	tion		(not gra	ded)
Forms of media							
	John Krumm, 2009	Ubiquitou	s Co	omputing	g Fundan	nentals, Crc Pr	Inc,
	Alessandro Acquisti, Stefans Gritzalis, Costos Lambrinoudakis, Digital Privacy: Theory, Technologies, and Practices, Auerbach Pubn, 2007						
Literature	Mireille Hildebrandt, Kieron O'Hara, Michael Waidner, Robert Madelin, Digital Enlightenment Yearbook 2013: The Value of Personal Data, Ios Press, 2013						
	Jan Camenisch Privacy and Id						
	Additional resolution	earch litera	tur	e will be	announc	ced during the	

Module	Network Se	Network Security							
MA-INF 3201									
Workload	Credit points	Duration	Freque	-					
180 h	6 CP	3 0							
Module	Prof. Dr. Pete	er Martini							
coordinator									
Lecturer(s)	Prof. Dr. Pete	er Martini, D		bil. Robe	rt Koch				
Classification	Programme		\mathbf{Mode}	Semes					
	M. Sc. Compu		Optiona						
Technical skills	The students l			-	•	y.			
	This includes 1								
	networks, cond	-			v				
	theseănetworks					on			
	techniques, the				nesses and a				
	discussion of u				1				
Soft skills	Theoretical ex		-	-	_				
	lecture topics a								
		eamwork to support time management, targeted organisation of							
	-	practical work and critical discussion of own and others' results.							
Contents		Threats and attack scenarios, cyber kill chain, organizational							
	aspects, technical aspects: securing networks using different								
	_	concepts like firewalls and IDS (intrusion detection systems),							
		security protocols for different protocol layers, penetration testing, high security networks, security aspects of IPv6, privacy							
		-	orks, secu	rity aspec	ets of IPv6, pri	vacy			
	protection, end								
Prerequisites	Recommended		cı ·	c					
	Bachelor level	_			-	S			
	(e.g. BA-INF				-	1: 1			
	`	ieior Prograi	ime imor	танк, ы	nglish lecture s	naes			
	available)			1 / 1	*** 11 101	CD			
D	Teaching forms	at Gi	oup size	h/week	Workload[h] 30 T / 45 S	CP			
Format	Lecture Exercises			$\frac{2}{2}$	30 T / 45 S	2.5 3.5			
			~ . .	I		0.0			
	T = face-to-face	ce teaching;	S = indep	pendent st		\			
Exam achievements	Written exam				\-	ded)			
Study achievements	Successful exer	rcise particip	ation		(not gra	ded)			
Forms of media		-		~					
	• William Stal								
	Principles and	`		, ,					
Literature	_			thusen: N	etzwerksicherh	eit,			
	Spektrum Aka		_	. ~					
	_	: Introduction	on to Con	aputer Se	curity, Addison	1			
	Wesley								

Module	Mobile Con	nmunicat	ion						
MA-INF 3202									
Workload	Credit points	Duration	Frequ	encv					
180 h	6 CP	1 semest	_	-					
Module		Prof. Dr. Peter Martini							
coordinator									
Lecturer(s)	Prof. Dr. Peter Martini, Dr. Matthias Frank								
. ,	Programme	,	Mode	Semes	ter				
Classification	M. Sc. Compu	iter Science		al $2. \text{ or } 3$	3.				
Technical skills	Knowledge ab		_						
					ogy independe	nt			
	and technology								
		_	, .	_	protocol layers				
					evaluate and a	ssess			
	scenarios with	communic	ation of m	obile devic	es. In-depth				
	understanding	of commu	nication p	aradigms o	f wireless/mob	ile			
	systems and n	etwork elei	ments, pro	ductive wo	rk in small gro	ups,			
	strengthening	skills on p	resentation	and discu	ssion of solution	ons			
	to current cha	llenges							
Soft skills	Theoretical ex	ercises to s	support in-	depth und	erstanding of				
	_	lecture topics and to stimulate discussions, practical exercises in							
		teamwork to support time management, targeted organisation of							
	practical work and critical discussion of own and others' results								
Contents	Mobility Management in the Internet, Wireless Communication								
	Basics, Wirele		_	_ ,	,				
	Communication			ıd data coı	mmunication),				
	Ad-hoc and Se		orks.						
Prerequisites	Recommended		c 1 ·	c					
		_			nication system	S			
	(e.g. BA-INF				v	l:daa			
	available) and	_			nglish lecture si	nues			
	Systems	Or WIA-IIV	L 9109 – 1	Thicipies (of Distributed				
	Teaching forma	at	Group size	h/week	Workload[h]	СР			
Format	Lecture		Group Size	2	30 T / 45 S	2.5			
Tormas	Exercises			$\frac{2}{2}$	30 T / 75 S	3.5			
	T = face-to-fa	ce teaching	$\mathbf{r} \cdot \mathbf{S} = \mathrm{ind} \epsilon$	1	,	1 3.3			
Exam achievements	Oral exam	cc tcaciiiig	3, D — IIId	pendent st		ded)			
Study achievements	Successful exer	rcise partic	ripation		(not gra				
Forms of media		Post of	P		(1100 810				
	• Jochen Schiller: Mobile Communications, Addison-Wesley,								
	2003			,	0 /				
T.,	• William Stallings: Wireless Communications and Networking,								
Literature	Prentice Hall,	_							
	• Further up-t	o-date lite	rature will	be annour	nced in due cou	ırse			
	• Further up-to-date literature will be announced in due course before the beginning of the lecture								

Module MA-INF 3207	Advanced I	Advanced Logic Programming						
Workload	Credit points	Duration	Frequen	CV				
180 h	6 CP	1 semester						
Module	Dr. Günter K		cvery ye	- CA1				
coordinator	Dr. Gunter K.	meser						
Lecturer(s)	Dr. Günter K	niesel						
Decturer(s)	Programme	meser	Mode	Semes	tor			
Classification	M. Sc. Compu	iter Science	Optional					
Technical skills	•				techniques and	to		
Technical skills	write clean bu		· .	_	•			
		0 0	`	J. U	ing the declara	tive		
	paradigm; con	•	•	0	0	101 V C		
	Prolog;	ipetelice in e	51116 0110 11	011 108100	i leavares or			
Soft skills		Skills in written and oral presentation of the solutions to						
Solv Simils					other students	s in		
	small teams	,	0011000100	,1011 ,,1011		, 111		
Contents	Quick refresh of logic programming basics and a Prolog							
	development environment, searching, understanding							
	backtracking and the cut, context arguments, difference lists,							
	data structures, constraint programming, meta-programming,							
	meta-interpret	, , , , , , , , , , , , , , , , , , ,		0,		5)		
	_			-	ng, logic progra	am		
	analysis.	,	0.1	Ü	<i>3</i> , <i>3</i> 1 <i>3</i>			
Prerequisites	Recommended	:						
-	Good knowled	ge of the fou	ndations of	of Logic I	Programming			
	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	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
Literature		E. Shapiro (e	d.): The <i>A</i>	Art of Pro	Prolog, Springer olog (2nd ed.) Press.			

Module	Seminar Selected Topics in Communication						
MA-INF 3209	Managemer	nt					
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	1 semester at least every year					
Module	Prof. Dr. Pete	er Martini					
coordinator							
Lecturer(s)	Prof. Dr. Pete	er Martini, F	rof. Dr. N	Iichael M	[eier		
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Computer Science		Optional	2. or 3	3.		
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	rs.					
Soft skills	Ability to pres	Ability to present and to critically discuss these results in the					
	framework of	the correspo	nding area	•			
Contents		rence and jo	ırnal pape	rs, currer	nt standardizat	ion	
	drafts						
Prerequisites	Required:						
		-			llowing lecture	s:	
	Principles of I						
	,	,		nmunicati	ion (MA-INF32	202),	
	IT Security (N)				
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Tormat	Seminar		10	2	30 T / 90 S	$\mid 4$	
	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	inced tow	ards the end o	f the	
Diterature	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	er at least every year					
Module	Prof. Dr. Pete	er 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	2. or 3.			
Technical skills		Ability to understand new research results presented in original						
	scientific pape	rs.						
Soft skills		Ability to present and to critically discuss these results in the						
	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	Freque	ncy				
120 h	4 CP	1 semeste	er every	year				
Module	P.D. Dr. Wolf	gang Koch						
coordinator								
Lecturer(s)	P.D. Dr. Wolfgang Koch							
Classification	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optiona	ıl 2.	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	Seminar Mo	del-Driv	en Softv	vare Eng	ineering		
MA-INF 3218							
Workload	Credit points	Duration	Freque	ncy			
120 h	4 CP	1 semeste	r every y	ear			
Module	Dr. Günter Kni	esel					
coordinator							
Lecturer(s)	Dr. Günter Kniesel						
Classification	Programme		Mode	Semester			
Classification	M. Sc. Compute	er Science	Optional	2.			
Technical skills	• Understand th	ne difference	s between	model drive	n and traditional		
	software development						
	• Describe the o	common fea	tures and p	eculiarities	of different model		
	driven developm						
					h for a given project		
	Select appropri				pment tasks		
	 Explain the individual scientific topic prepared Refinement of scientific writing and presentation skills 						
Soft skills			_	-			
	_		given subject				
	• Distill and communicate the summary of a computer science topic						
	orally						
	 Evaluate the scientific integrity of a written summary Use modern presentation software 						
<u> </u>				, , 1	1 41 1 T		
Contents	Model driven software development concepts, tools and methods. In						
	particular:						
	• Models, meta-		meta-meta	a-models (G	eneral, MOF,		
	EMOF, ECORE						
	• Text to model						
	• Imperative ver						
	Model-driven			-			
D	Best practice		1 issues in	model based	development		
Prerequisites	Recommended:		r' - D				
	MA-INF 3207 – Teaching forms				Workload[h] CP		
Format	Seminar	11 '	Group size	h/week	30 T / 90 S 4		
				-	001/905 4		
	T = face-to-face			ndent study	/ 1 1		
Exam achievements	Oral presentation	on, written i	eport		(graded)		
Study achievements	337.1	// 11	1	1 /4 1:	(not graded)		
Forms of media		- , ,	.1a1.un1-bor	ın.de/teacnı	ng/seminars/start		
	Slides (Power)Mailing list fo	' '					
			Davalonmor	t. Technolo	gy, Engineering,		
	Management".						
					eydeda, Matthias		
Literature					-7, Springer 2005		
					Applying MDA to		
	Enterprise Com				-rr-/o		

Module MA-INF 3219	Lab Model-	Driven S	oftware 1	Engineer	ring			
Workload	Credit points	Duration	Frequer	ıcv				
270 h	9 CP	1 semester	_	-				
Module	Dr. Günter Kni	iesel						
coordinator								
Lecturer(s)	Dr. Günter Kni	iesel						
Classification	Programme		Mode	Semester				
Classification	M. Sc. Comput		Optional	2.				
Technical skills	On successful co	ompletion of	this modul	e, students	should be able	to:		
	 Describe the process of model driven software development (MDS) and support this description with personal experiences Connect model driven software development guidelines to concrepractical examples Be able to use one or several concrete MDSD tools and technique and explain their use to others 							
Soft skills	Students should	l be able to:						
	 Run a software project based on MDSD tools, techniques and methods Establish and iteratively evolve a project plan Collaborate in a team Estimate the required time and other resources for given tasks 							
	_							
Contents		Manage a software development project with time constraints						
Contents	Model driven software development methods are the key to a new level of automation and tool integration in software development. Students will learn how MDSE concepts, tools an methods boost the development of general purpose and domain specific languages, leverage software							
D 11	quality analysis tools and foster automated software improvement.							
Prerequisites	Required: MA INE 2218 Comings Model Driven Software Engineering							
	MA-INF 3218 – Seminar Model-Driven Software Engineering The seminar lays the conceptual foundations for the work in the lab.							
Format	Teaching forms Lab	at (Froup size 8	h/week	Workload[h] 60 T / 210 S	CP 9		
				_	'	9		
	T = face-to-face teaching; $S = $ independent study							
Exam achievements	Oral presentation	on, written r	eport		, , ,	aded)		
Study achievements Forms of media	• Web page bt	tna / /aavrilri	iai uni han	n do/tooghi	(not gr	aded)		
rorms of media	• Web page: https://sewiki.iai.uni-bonn.de/teaching/labs/start							
	Slides (Powerpoint/PDF)Wiki as a shared knowledge base							
	• Task Tracking		-	r Physical))			
	• Shared reposi	- "		,				
	Mailing list							
Literature	 "Model-Driven Software Development: Technology, Engineering, Management". Thomas Stahl, Markus Voelter, Wiley 2006. "Model-Driven Software Development". Sami Beydeda, Matthias Book, Volker Gruhn (Eds), ISBN 978-3-540-25613-7, Springer 2005 David S. Frankel: Model Driven Architecture: Applying MDA to Enterprise Computing, John Wiley 							
	• Modellgetrieb Management. d			g, Technike	en, Engineering,			

Module	eSecurity							
MA-INF 3222								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semeste	r every					
Module	Prof. Dr. Joac	Prof. Dr. Joachim von zur Gathen						
coordinator								
Lecturer(s)	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken							
Classification	Programme		Mode	Seme	ster			
Classification	_	M. Sc. Computer Science Optional 2.						
Technical skills	Understanding	g of security	concerns	and meas	sures, and of the	9		
	interplay betw	nterplay between computing power and security requirements in						
	the realm of re	he realm of real-world applications, in particular internet-based						
	ones. Mastery	nes. Mastery of advanced techniques for the design of						
	cryptosystems	cryptosystems and practical cryptanalysis.						
Soft skills	Oral presentat	Oral presentation (in tutorial groups), written presentation (of						
	exercise solution	ons), team	collaborat	ion in sol	ving homework			
	problems, criti	ical assessm	ent.					
Contents	First focus: se	curity on th	e interne	t and secu	re protocols.			
	Furthermore:	at least one	real worl	d applicat	tion, for exampl	e		
	• electronic he	ealth cards,						
	• electronic ele	,						
	• electronic pa	ssports.						
Prerequisites	Required:							
	MA-INF 1103	- Cryptogr	aphy					
	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	ce teaching	S = inde	ependent s	study			
Exam achievements	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise partici	pation		(not gra	ded)		
Forms of media								
Literature	Varying accord	ding to the	selected t	opic				

Module MA-INF 3227	Seminar An	onymity a	nd Priva	acy on t	the Internet		
Workload	Credit points	Duration	Frequer	ıcy			
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Björn Scheuermann						
coordinator							
Lecturer(s)	Prof. Dr. Björ	Prof. Dr. Björn Scheuermann					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	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	ne	
	framework of t	he correspor	nding area				
Contents	Current conference	ence and jou	ırnal 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-face	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentati	ion, written	report		(gra	ded)	
Study achievements					(not gra	$\overline{\operatorname{ded}}$	
Forms of media							
Literature							

Module	Lab IT-Security						
MA-INF 3229							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste	r every	semester			
Module	Prof. Dr. Mic.	hael Meier	•				
coordinator							
Lecturer(s)	Prof. Dr. Mic.	Prof. Dr. Michael Meier					
Classification	Programme		Mode	Seme	Semester		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	2. or 3.		
Technical skills	The students will carry out a practical task (project) in the						
	context of IT Security, including test and documentation of the						
	implemented s	implemented software/system.					
Soft skills	Ability to prop	perly preser	t and def	end design	n decisions, to		
	prepare readal	ole docume	ntation of	software;	skills in		
	constructively	collaborati	ng with of	thers in sr	nall teams over	a	
	longer period	of time; abi	ity to clas	ssify ones	own results into	o the	
	state-of-the-ar	t of the resp	o. area				
Contents							
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	ependent s	study		
Exam achievements	Oral presentat	ion, writter	report		(gra	ided)	
Study achievements					(not gra	ded	
Forms of media							
Literature							

Module	Advanced S	ensor Dat	a Fusion	in Dist	tributed		
MA-INF 3233	Systems						
Workload	Credit points	Duration	Freque	псу			
180 h	6 CP	3 3					
Module	PD Dr. Wolfg	ang 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						
		·			ular to improve		
	_	-	_	_	nsors. This im	_	
	_				hodologies such		
					d correlations of		
		_			nication links l		
		,		-	have to be app	-	
					be computed.		
	Once recieved at a fusion center (FC), the tracks then are fused						
	to reconstruct a global estimate. In this lecture, methodologies						
	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 Ka						
Soft skills	Mathematical						
	mathematical		_				
Contents					ıla, the Federat	ted	
	Kalman Filter	, naive fusion	n, the dist	ributed K	Kalman filter ar	nd	
	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 – Introduction to Sensor Data Fusion - Methods					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-fa	ce teaching:	S = index	endent st	cudy		
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	
		_			_		
Literature	Framework and Selected Applications", Springer, 2014. 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	Lab Mobile	Sensing S	ystems					
MA-INF 3234								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every	year				
Module	JunProf. Dr.	Delphine Cl	nristin					
coordinator								
Lecturer(s)	JunProf. Dr.	Delphine Ch	nristin					
. ,	Programme	1	Mode	Seme	ster			
Classification	M. Sc. Compu	ter Science	Options	al 2. or	3.			
Technical skills	The students v				ctical solutions			
		_	_	_	ile sensing syste	ms,		
					he corresponding			
	infrastructure.	8				3		
Soft skills	Organized in s	mall teams, 1	the stude	ents will i	interact and			
	_				l analyze the des	sign		
	_	_	-	-	is analysis. The	0		
	_	_			ill be documente	ed in		
	a written repo		_					
Contents		Mobile sensing systems leverage mobile phones as a new						
	_	, ,	0	•	sensors, such as			
	_							
		cameras, microphone, GPS, and accelerometers, are used to capture contextual information about the users and their						
	_				of this lab, the			
	_			_	challenging resea	rch		
	field by addres	-						
		_						
	• New mobile	_				_		
	_			-	ous contributions	8		
	• Incentive sch		ourage u	sers cont	ributions			
D	• Usable priva							
Prerequisites	Recommended MA-INF 3202		mmunica	ation				
	Teaching forma	at Gro	up size	h/week	Workload[h]	CP		
Format	Lab		8	h/week	Workload[h] 60 T / 210 S	9		
		1	'					
				pendent s				
Evam achievements	T = face-to-face teaching; S = independent study Oral presentation, written report (graded)							
Exam achievements								
Study achievements	Orar presentat	ion, written	report		(grad (not grad			
	_				(not grad	ded)		
Study achievements	Burke, J., Esta	rin, D., Hanse	en, M., I	,	(not grad	ded)		
Study achievements	Burke, J., Esta Reddy, S., Sriv	rin, D., Hanse	en, M., I	rticipator	(not grade, Ramanathan, ry sensing. In:	ded)		
Study achievements	Burke, J., Esta Reddy, S., Sriv Proceedings of	rin, D., Hanse vastava, M., 2 5 the 1st Wor	en, M., I	rticipator	(not grade, Ramanathan, ry sensing. In:	ded)		
Study achievements	Burke, J., Esta Reddy, S., Sriv	rin, D., Hanse vastava, M., 2 5 the 1st Wor	en, M., I	rticipator	(not grade, Ramanathan, ry sensing. In:	ded)		
Study achievements	Burke, J., Esti Reddy, S., Sriv Proceedings of (WSW), pp. 1	rin, D., Hanse vastava, M., 2 the 1st Wor -5.	en, M., I 2006. Pa kshop oi	rticipator n World-	(not grade, Ramanathan, ry sensing. In:	ded) N.,		
Study achievements	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A.,	rin, D., Hanse vastava, M., 2 5 the 1st Wor -5. Eisenman, S	en, M., I 2006. Pa kshop or ., Lane,	rticipator n World- : N., Miluz	(not grade), Ramanathan, by sensing. In: Sensor-Web	N.,		
Study achievements	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-o	rin, D., Hanse vastava, M., 2 5 the 1st Wor -5. Eisenman, S centric urban	en, M., I 2006. Pa kshop or ., Lane, sensing.	rticipator n World- N., Miluz In: Proc	(not grade, Ramanathan, Ty sensing. In: Sensor-Web zo, E., Peterson,	N., R., and		
Study achievements	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-o	rin, D., Hanse vastava, M., 2 5 the 1st Wor -5. Eisenman, S centric urban	en, M., I 2006. Pa kshop or ., Lane, sensing.	rticipator n World- N., Miluz In: Proc	(not grader, Ramanathan, Pry sensing. In: Sensor-Web 220, E., Peterson, Reedings of the 21	N., R., and		
Study achievements Forms of media	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-o Annual Interna pp. 18–31.	rin, D., Hanse vastava, M., 2 5 the 1st Wor -5. Eisenman, S centric urban ational Wirel	en, M., I 2006. Pa kshop on ., Lane, sensing. ess Inter	rticipator n World- N., Miluz In: Proc enet Confe	(not grade), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, eeedings of the 2derence (WICON)	N., , R., and),		
Study achievements Forms of media	Burke, J., Estr Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-of Annual Internation pp. 18–31. Campbell, A.,	rin, D., Hanse vastava, M., 2 7 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter	rticipator n World- N., Miluz In: Proc enet Confe N., Miluz	(not grades), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, seedings of the 2derence (WICON) zo, E., Peterson,	N., , R., and), , R.,		
Study achievements Forms of media	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-of Annual Internation pp. 18–31. Campbell, A., Lu, H., Zheng,	cin, D., Hanse vastava, M., 2 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S X., Musoles	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter ., Lane, i, M., Fo	rticipator n World- N., Miluz In: Proc enet Confe N., Miluz dor, K., 1	(not grade), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, eedings of the 2derence (WICON) zo, E., Peterson, Eisenman, S., Al	N., , R., and), , R.,		
Study achievements Forms of media	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-o Annual Interna pp. 18–31. Campbell, A., Lu, H., Zheng, G., 2008. The	rin, D., Hanse vastava, M., 2 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S X., Musoles rise of people	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter ., Lane, i, M., Fo	rticipator n World- N., Miluz In: Proc enet Confe N., Miluz dor, K., 1	(not grades), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, seedings of the 2derence (WICON) zo, E., Peterson,	N., , R., and), , R.,		
Study achievements Forms of media	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-of Annual Internation pp. 18–31. Campbell, A., Lu, H., Zheng, G., 2008. The Computing 12	rin, D., Hanse vastava, M., 2 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S X., Musoles rise of people, 12-21.	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter ., Lane, i, M., Fo	n World- N., Miluz In: Proc enet Confe N., Miluz dor, K., I sensing.	(not grade), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, seedings of the 2derence (WICON) zo, E., Peterson, Eisenman, S., All IEEE Internet	N., , R., nd), , R.,		
Study achievements Forms of media	Burke, J., Esta Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-of Annual Internation pp. 18–31. Campbell, A., Lu, H., Zheng, G., 2008. The Computing 12 Christin, D., F	rin, D., Hanse vastava, M., 2 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S X., Musoles rise of people , 12–21. Reinhardt, A.	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter ., Lane, i, M., Fo e-centric	rticipator n World- N., Miluz In: Proc enet Confe N., Miluz dor, K., I sensing.	(not grade), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, seedings of the 2derence (WICON) zo, E., Peterson, Eisenman, S., Alderence Internet llick, M., A surv	N., R., nd), R., hn,		
Study achievements Forms of media	Burke, J., Estr Reddy, S., Sriv Proceedings of (WSW), pp. 1 Campbell, A., 2006. People-of Annual Internation pp. 18–31. Campbell, A., Lu, H., Zheng, G., 2008. The Computing 12 Christin, D., Fon privacy in the	rin, D., Hanse vastava, M., 2 the 1st Wor -5. Eisenman, S centric urban ational Wirel Eisenman, S X., Musoles rise of people , 12–21. Reinhardt, A. mobile partic	en, M., I 2006. Pa kshop or ., Lane, sensing. ess Inter ., Lane, i, M., Fo e-centric , Kanher ipatory s	N., Miluz In: Proceed Confe N., Miluz dor, K., I sensing.	(not grade), Ramanathan, by sensing. In: Sensor-Web zo, E., Peterson, seedings of the 2derence (WICON) zo, E., Peterson, Eisenman, S., All IEEE Internet	N., , R., nd), , R., hn,		

Module MA-INF 3235	Usable Security	and P	rivacy				
Workload	Credit points Dur	ation	Freque	ncy			
180 h		emester	every y	ear			
Module	Prof. Dr. Matthew	Smith					
coordinator							
Lecturer(s)	Prof. Dr. Matthew	Smith					
Classification	Programme	_•	Mode	Semest	ter		
m 1 ' 1 1'11	M. Sc. Computer S		Optiona		one of IT good		
Technical skills	and privacy mechan usability of IT secu	Students will be familiar with usability problems of IT security and privacy mechanisms, understand methods for exploring usability of IT security and privacy mechanisms as well being able to design and execute usability studies.					
Soft skills	• Working with scie	entific lit	erature				
	• Communication s	kills					
	• Team working ski	• Team working skills					
Contents	The lecture on Usable Security and Privacy deals with many aspects of human factors and usability in the context of security and privacy. The lecture includes both the foundations of usable 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 & production of technology Design and evaluation of new usable security & private technology Impact of organizational policy on security and privatint interaction Lessons learned from designing, deploying, managing evaluating security & privacy technologies Foundations of usable security & privacy Methodology for usable security & privacy research Ethical, psychological, sociological and economic asperts 						
Prerequisites	security & privacy	ecnnoio	gies				
Frerequisites	Required: Knowledge about IT Security is advantageous but not mandatory.						
	Recommended:						
	At least 1 of the following:						
	BA-INF 138 – IT-Sicherheit						
	BA-INF 136 – Real	tive Sic	herheit				
	MA-INF 1103 – Cr						
	MA-INF 3229 – La						
	Teaching format		oup size	h/week	Workload[h]	СР	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			$\frac{2}{2}$	30 T / 75 S	3.5	
	T = face-to-face tea	ching S	S — inder		,	1	
Exam achievements	Written exam	ioning, c	, — mueț	chacht St		ded)	
Study achievements	Successful exercise	particips	ation		(not gra		
Forms of media	Successiul exercise	e ar ororpe	~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~		(110) 814	404)	
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							
Lecturer(s)	Prof. Dr. Micl	hael Meier	1				
Classification	Programme		Mode	Semest			
	M. Sc. Computer Science Optional 1. or 2						
Technical skills		Students are introduced to selected active research fields of IT					
		security and gain deep knowledge of the research literature.					
		Students learn selected aspects of IT security. This includes					
			-		n technology as	S	
	_	well as concepts to increase the level of IT security, their					
	applications ar	applications and their weaknesses.					
Soft skills	Theoretical ex	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	Array Signal and Multi-channel Processing					
MA-INF 3237						
Workload	Credit points	Duration	Frequen	cy		
180 h	6 CP 1 semester every year					
Module	Prof. Dr. Wol	fgang Koch				
coordinator						
Lecturer(s)	Dr. Marc Oisp	ouu				
Classification	Programme		Mode	Semes	ter	
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.	
Technical skills	Localization of	f multiple so	urces using	g passive	sensors is a	
	fundamental t	ask encounte	red in vari	ous field	s 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	es are prese	ented. Fu	irthermore, the	
	sensor calibrat	ion, directio	n finding,	and bear	ings-only	
	localization pr	oblem are co	nsidered.	Special a	pplications are	
	emphasized, li	ke small airb	orne array	s for unr	nanned aerial	
	vehicles (UAV	s).				
Soft skills	Mathematical	derivation o	f algorithm	ıs, applic	ations of	
	mathematical					
Contents	Estimation the	. ,	,		,	
	conventional b	eamforming	Multiple	Signal Cl	lassification	
	, , , , , , , , , , , , , , , , , , , ,			-	calization, Direct	
	Position Deter	mination (D	PD), $Appl$	ications		
Prerequisites	Recommended					
	Recommended			ons of Au	ıdio Signal	
	Processing" (N					
	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	cudy	
Exam achievements	Oral Exam				(graded)	
Study achievements	Successful exe	rcise particip	ation		(not graded)	
Forms of media	Power Point					
	H. L. van Tree	, -	·	_		
Literature	Detection, Est		l Modulati	on Theor	ry. New York:	
	Wiley-Interscie	ence, 2002.				

Module	Lab Commi	ınication	and Co	mmunic	ating Devices	\mathbf{s}	
MA-INF 3304							
Workload	Credit points	Duration	Frequ	ency			
270 h	9 CP	1 semest	er every	every semester			
Module	Prof. Dr. Pete	er 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 will carry out a practical task (project) in the						
	context of communication systems, including test and						
	documentation	documentation of the implemented software/system.					
Soft skills	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	Lab Information Systems						
MA-INF 3305							
Workload	Credit points	Duration	Freque	•			
270 h	9 CP 1 semester at least every year						
Module	Dr. Thomas Bode						
coordinator							
Lecturer(s)	Dr. Thomas E	Bode					
Classification	Programme		Mode	Seme	Semester		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.		
Technical skills	The students	will carry ou	t a pract	ical task ((project) in the		
	context of info	context of information systems, 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 documer	tation of	software;	skills in		
	constructively	collaboratin	g with of	thers in sr	nall teams over	a	
	longer period	of time; abil	ity to clas	ssify ones	own results into	o the	
	state-of-the-ar	t of the resp	. area				
Contents	Varying select	ed topics clo	se to cur	rent resea	rch in the area	of	
	database- and	information	systems.				
Prerequisites	none						
To 4	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	ependent s	study		
Exam achievements	Oral presentat	ion, written	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 MA-INF 3309	Lab Malwai	re Analysi	S				
Workload	Credit points	Duration	Freque	Frequency			
270 h	9 CP	1 semester	every	every semester			
Module	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	will carry ou	t a pract:	ical task ((project) in the		
	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;						
		ability to make design decisions in a practical task; present 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 MA-INF 3310	Introduction Application		r Data 1	Fusion -	Methods a	nd	
Workload	Credit points	Duration	Freque	-			
180 h	6 CP 1 semester every year P.D. Dr. Wolfgang Koch						
Module	P.D. Dr. Wolf	gang Koch					
coordinator							
Lecturer(s)	P.D. Dr. Wolfgang Koch						
Classification	Programme		Mode	Semest	ter		
	M. Sc. Compu		Optiona		1		
Technical skills		_			theory of senso		
				-	ries on how to		
	handle uncertain data and knowledge within analytical calc						
	,				an filter is deri		
		_			aches to a wide		
	spectrum of a	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 much more will be presented.						
Soft skills	Mathematical				ration of		
Soft Skills	mathematical		_		au1011 01		
Contents	Gaussian prob				an filter		
Contents	_	· ·	•	,	,	r	
	Multi-Hypothesis-Trackier, Interacting Multiple Model Filter, Retrodiction, Smoothing, Maneuver Modeling						
Prerequisites	none	omooning, w	Tancaver	Wiodeiing)		
Trerequisites		ot Cn	oup sizo	h /wools	Workload[h]	CD	
Farmet	Teaching forms	at Gr	oup size	h/week	Workload[h] 30 T / 45 S	2.5	
Format	Lecture			$\frac{2}{2}$	30 T / 45 S 30 T / 75 S	1	
	Exercises				'	3.5	
	T = face-to-fa	ce teaching; S	S = indep	endent st			
Exam achievements	Oral exam				(gra	ded)	
Study achievements	Successful exe	rcise participa	ation		(not gra	ded)	
Forms of media							
	W. Koch: "Tracking and Sensor Data Fusion: Methodological						
-	Framework an	d Selected A ₁	pplication	ns", Spring	ger, 2014.		
Literature	Y. Bar-Shalon	n: "Estimatio	n with A	pplication	s to Tracking	and	
	Y. Bar-Shalom: "Estimation with Applications to Tracking and Navigation", Wiley-Interscience, 2001.						

Module	Topics in Applied Cryptography							
MA-INF 3311								
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semester	every					
Module	Prof. Dr. Joac	chim von zur	Gathen					
coordinator								
Lecturer(s)	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken							
Classification	Programme Mode			Semes	ster			
Classification	M. Sc. Computer Science Optional 3.			al 3.				
Technical skills	Gain deeper understanding in a special area of cryptography							
	close to current research.							
Soft skills	Oral presentation (in tutorial groups), written presentation (of							
	exercise solution	exercise solutions), team collaboration in solving homework						
	problems, critical assessment.							
Contents	One varying, advanced topic related to current research in							
	applied crypto	graphy, e.g.						
	• mobile secur	ity, or						
	• design and a	nalysis of ha	sh functi	ons.				
Prerequisites	Required:							
	MA-INF 1103	- Cryptogra	phy					
	and one further	er course in o	rvptogra	phy like T	Γhe Art of			
	Cryptography			r J				
	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	Written exam				(gra	ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
Literature								

Module MA-INF 3312	Lab Sensor Data Fusion					
Workload	Credit points	Credit points Duration Frequency				
270 h	9 CP 1 semester every year					
Module	P.D. Dr. Wolf	P.D. Dr. Wolfgang Koch				
coordinator						
Lecturer(s)	P.D. Dr. Wolf	gang Koch				
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	iter Science	Option	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 shall work together in a team. Everyone is					
	responsible for	a specific	part in th	e context	of a main goal.	
	Results will be	e exchange	and integ	grated via	software interfa	aces.
Contents	Varying selected	ed topics of	n sensor d	ata fusion	l .	
Prerequisites	none					
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	The relevant literature will be announced at the beginning of the					
Diterature	lab.					

Module MA-INF 3317	Seminar Sel	Seminar Selected Topics in IT Security					
Workload	Credit points	Credit points Duration Frequency					
120 h	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.	2.		
Technical skills	Ability to understand new research results presented in original						
	scientific paper	scientific papers.					
Soft skills	Ability to present	ent and to c	ritically di	scuss the	se results in th	ne	
	framework of t	he correspond	nding area	•			
Contents	Current confer	ence and jou	rnal pape	rs			
Prerequisites	none						
Format	Teaching forma	ıt 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 presentati	ion, written	report		(gra	ded)	
Study achievements		(not graded)					
Forms of media							
Literature							

Module MA-INF 3318	Seminar Ve	rification o	of Comp	lex Syst	tems			
Workload	Credit points	Duration	Frequer	ncv				
120 h	4 CP	1 semester						
Module	JunProf. Dr.) 50225			
coordinator								
Lecturer(s)	JunProf. Dr.	Janis Voigt	länder					
	Programme	0	Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optional	l 2. or 3	3.			
Technical skills	Knowledge in	topics in the	area of sp	pecifying	and verifying			
	behaviour of c	omplex syste	ms such a	as softwar	e. Competenc	e to		
	mine for profo	und knowled	ge about a	a given su	ıbject, in parti	cular		
	acquiring and studying original literature. Understanding scientific publications, often written tersely. Distilling this into							
	suitable presentations; determination of relevant vs. irrelevant							
		material. Presenting research results to others, in writing and in oral presentations, and discussing them with an audience.						
	_	,	_					
	Ability to disc		_			ents,		
Soft skills	and to constructively deal with critical feedback by others. Communication skills (preparing and presenting talks, using							
Soft Skills	visual media,	\	_	-		-		
	skills (motivat				, ,			
	,	_		-	=	aracc		
	criticism), self competences (time management with long-ranging deadlines, self-study, ability to analyse, creativity).							
Contents	Techniques for analyzing the correctness of complex systems							
	such as software. Theoretical foundations for such techniques, as							
	well as conside	eration of pra	actical too	ls. Specti	rum ranging fr	rom		
	formal to semi	-formal; posi	tioning of	techniqu	es within this			
	spectrum. Spe	ecific themes	of interest	t include:				
	Specification	formalisms	and langu	ages				
	• Decision pro			J				
	Modelling de	esired proper	ties of a s	ystem				
	Model check	_						
	• Theorem pro	_						
	• Static (flow)	-		erpretatio	n			
	• Code analys	_						
	• Testing (app	,	,	_	/			
	• Runtime ver	*			itoring)			
	Applications	and pragma	tics of vei	rification				
	A selection of	topics will b	e made in	each sem	nester.			
Prerequisites	none				T			
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa			endent st				
Exam achievements	Oral presentat	ion, written	report		. ,-	aded)		
Study achievements					(not gra	aded)		
Forms of media			,					
Literature	The relevant l	iterature will	be annou	inced in t	ime.			

Module	Lab Usable Security and Privacy						
MA-INF 3319							
Workload	Credit points	Credit points Duration Frequency					
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Matthew Smith						
coordinator							
Lecturer(s)	Prof. Dr. Mat	thew Smith					
CI 'C '	Programme		Mode	Semes	ster		
Classification	M. Sc. Compu	iter Science	Optiona	d 2.			
Technical skills	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	a great degr	ee of free	dom to c	hose their own		
	topics within t	the context of	f human	aspects o	of security and		
	privacy.						
Prerequisites	Required:						
	MA-INF 3235	– Usable Se	curity and	d Privacy			
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	pendent s	study		
Exam achievements	Oral presentat	tion, written	report		(gra	ided)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 3320	Lab Securit	y in Dist	ributed	Systems	3		
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste	er every	year			
Module	Prof. Dr. Mat	thew Smith					
coordinator							
Lecturer(s)	Prof. Dr. Matthew Smith						
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2.			
Technical skills	The students	will carry o	it a pract	ical task	(project) in the		
	context of dist	ributed sec	urity, incl	ıding doc	umentation of t	he	
	implemented software/system.						
	Strong progra	Strong programming skills required.					
Soft skills		Ability to properly present and defend design decisions, to					
		prepare readable documentation of software; skills in					
				,	mall teams over	a	
	_		_		own results into		
	state-of-the-ar		-	J			
Contents	Security in dis			luding an	nongst others:		
	• Secure Mess	aging					
	App Security	y					
	• SSL/HTTPS	S					
	API Security	у					
	Machine Lea	arning for S	ecurity				
	• Passwords						
	• Intrusion De	etection Sys	tems				
	• Anomaly De						
	• Security Vis	ualisation					
Prerequisites	none						
Format	Teaching form	at G	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, writter	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature							

Module MA-INF 3321	Seminar Usable Security and Privacy							
Workload	Credit points	Duration	Frequen	ıcy				
120 h	4 CP 1 semester every year							
Module	Prof. Dr. Mat	Prof. Dr. Matthew Smith						
coordinator								
Lecturer(s)	Prof. Dr. Matthew Smith							
Classification	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	ter Science	Optional	2.	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		
Format	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 graded)							
Forms of media								
Literature								

Module MA-INF 3322	Program A	nalysis an	d Binary	Exploi	tation			
Workload	Credit points	Duration	Frequen	.cy				
180 h	6 CP	1 semester	every year	ar				
Module	Prof. Dr. Peter	Martini						
coordinator								
Lecturer(s)	Prof. Dr. Peter			dilla				
Classification	Programme		Mode	Semester				
	M. Sc. Comput		1	2. or 3.	(0: 1.1			
Technical skills	Static and dynamic program analysis, Exploitation (Stack-based Buffer Overflows, Format String Exploits, Heap Exploitation, Use-After-Free Exploits) and Countermeasures (Stack Cookies, NX, ASLR, RELRO)							
Soft skills	Vulnerability D	Vulnerability Discovery in Computer Programs, Application of taught Techniques, Working with Binary Representations, Assembly						
Contents	Our computers that the source those programs during the deve circumstances) arbitrary code of find well known	run a lot of code of those contain bugs lopment. The been exploited execution. In exploitable	elosed source e programs , mistakes ose bugs co by attacker this lecture ougs and he	that the probability of the control	rograms meanir lable. Naturally rogrammer mad certain may lead to be teach you how bit them.	e to		
	You will first learn about basic binary program analysis such as static and dynamic analysis. After this introduction we will talk about vulnerability discovery in general meaning that you will learn how to find exploitable bugs by yourself. Next we move on to basic stack-based buffer overflows and add mitigation techniques (stack cookies, NX, ASLR, RELRO,) as we progress and exploit them as well. After we finished the topic of stack-based buffer overflows we move on to more advanced topics such as format string exploits, heap exploitation, use-after-free exploits and others. The lecture ends with a practical fuzzing example and a vulnerability analysis of an open-source mail server.							
Prerequisites	Required:							
	none Recommended: You should have an equivalent knowledge as presented in the lectures "Kommunikation in verteilten Systemen", "Systemnahe Programmierung" (bonus: "Malware Boot Camp" and "Reaktive Sicherheit")							
	You should also (including Bash					CIII		
	Teaching forma	<u>′ </u>	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	a teaching: S	- indoper	1	, , , , ,	1		
Exam achievements	Oral or written (graded)				nalified students)		
Study achievements	Successful exerc	ise participa	ion		(not gr	aded)		
Forms of media	Successiui exerc	no participa	.1011		(Hot gi	aucu)		
Literature	The relevant litelecture	erature will b	e announce	ed at the b	eginning of the			

Module	Lab Fuzzing Bootcamp							
MA-INF 3323								
Workload	Credit points	Duration	Fre	Frequency				
270 h	9 CP 1 semester every year							
Module	Prof. Dr. Mat	Prof. Dr. Matthew Smith						
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 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 MA-INF 3324	Lab Design	of Usab	e Securi	ty Med	chanisms		
Workload	Credit points	Duration	Frequ	ency			
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Mat	thew Smit	h				
coordinator							
Lecturer(s)	Dr. Emmanuel von Zezschwitz						
Classification	Programme		Mode	Sen	nester		
Classification	M. Sc. Compu	iter Science	e Option	al 2. c	or 3.		
Technical skills	The students will carry out a practical task (project) in the						
	context of usable security mechanisms, including test and						
	documentation of the implemented software/system.						
Soft skills	Ability to prop	perly prese	nt and de	end desi	gn decisions, to		
	prepare readal	ble docume	entation of	softwar	e; skills in		
	constructively	collaborat	ing with c	thers in	small teams over	a	
	longer period	of time; ab	ility to cla	ssify one	es own results int	o the	
	state-of-the-ar	t of the res	sp. area				
Contents							
Prerequisites	none						
Format	Teaching forms	at C	roup size	h/weel	workload[h]	CP	
rormat	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching	g; S = ind	ependent	study		
Exam achievements	Oral presentat	ion, writte	n report		(gra	aded)	
Study achievements		<u> </u>			(not gra	aded)	
Forms of media							
Literature							

4 Intelligent Systems

MA-INF 4111	L2E2	6 CP	Intelligent Learning and Analysis Systems: Machine	100
NEA THE MAIN	T OFFO	a CD	Learning	
MA-INF 4112	L2E2	6 CP	Intelligent Learning and Analysis Systems: Data Mining	
MA-INF 4113	LODO	c CD	and Knowledge Discovery	
			Cognitive Robotics	
MA-INF 4114			Robot Learning	
MA-INF 4201		6 CP	Artificial Life	
MA-INF 4203			Autonomous Mobile Systems	
MA-INF 4204			Technical Neural Nets	
MA-INF 4207			Dynamically Reconfigurable Systems	
MA-INF 4208			Seminar Vision Systems	110
MA-INF 4209	Sem2	4 CP	Seminar Principles of Data Mining and Learning	
			Algorithms	
MA-INF 4210			Seminar Advanced Topics in Technical Informatics	
MA-INF 4211	Sem2	4 CP	Seminar Cognitive Robotics	
MA-INF 4212			Data Science and Big Data	
MA-INF 4213	Sem2	4 CP	Seminar Humanoid Robots	115
MA-INF 4214	Lab4	9 CP	Lab Humanoid Robots	116
MA-INF 4215	L2E2	6 CP	Humanoid Robotics	117
MA-INF 4216	L2E2	6 CP	Data Mining and Machine Learning Methods in	
			Bioinformatics	118
MA-INF 4217	Sem2	4 CP	Seminar Machine Learning Methods in the Life	
			Sciences	119
MA-INF 4218	Lab4	9 CP	Lab Modeling and Simulation	120
MA-INF 4226	Lab4	9 CP	Lab Parallel Computing for Mobile Robotics	121
MA-INF 4228	L4E2	9 CP	Foundations of Data Science	122
MA-INF 4229	L4E2	9 CP	Pattern Recognition (1)	123
MA-INF 4302	L2E2	6 CP	Advanced Learning Systems	124
MA-INF 4303	L2E2	6 CP	Learning from Non-Standard Data	125
MA-INF 4304			Lab Cognitive Robotics	
MA-INF 4306	Lab4	9 CP	Lab Development and Application of Data Mining and	
			Learning Systems	127
MA-INF 4307	Lab4	9 CP	Lab Field Programmable Gate Arrays	
			Lab Vision Systems	
MA-INF 4309			Lab Sensor Data Interpretation	
MA-INF 4310			Lab Mobile Robots	
			Semantic Data Web Technologies	
MA-INF 4313			Seminar Semantic Data Web Technologies	
MA-INF 4314			Lab Semantic Data Web Technologies	
MA-INF 4318			Seminar Representation Learning for Big Data	101
1010	50III2	1 01		135
MA-INF 4319	L4E2	9 CP	Game AI	
MA-INF 4320			Lab Representation Learning on Graphs	
MA-INF 4321			Seminar Learning from Time Series	
MA-INF 4323			Pattern Recognition (2)	
MA-INF 4324			Seminar Advanced Topics in Data Science	
			Lab Data Science in Practice	
MILL-IIMI, 4979	Lab4	$\sigma \odot \mathbf{I}$	Day Dava Delette III I I active	144

Module MA-INF 4111	Intelligent I Learning	Learning	and .	Anal	ysis Sys	stems: Mach	ine		
Workload	Credit points	Duration	F	requen	ıcv				
180 h	6 CP	1 semeste		very y	-				
Module	Prof. Dr. Stefa	an Wrobel		0 0					
coordinator									
Lecturer(s)	Prof. Dr. Stefa	an Wrobel							
	Programme		Mo	ode	Semest	ter			
Classification	M. Sc. Compu	iter Science	е Ор	tional	1. or 2	2.			
Technical skills	-					dules in which			
		This module is one of two complementary modules in which students gain an understanding of the most important							
	paradigms and	l methods	of inte	- elligent	learning	systems as th	ey		
	are used in dat	ta analysis	and/c	or for	implemen	nting adaptive			
	behaviour (ma	chine learn	ning, d	lata m	ining, kn	owledge discov	ery		
	in databases).	This modu	ıle cor	ncentr	ates on th	he core task of			
	predictive lear	ning from o	examp	oles an	d on age	nt learning, an	d		
	teaches the ma		_				e		
	end of the mod				_	_			
	appropriate me				-	-			
	learning applic					_			
	results, and will know where to start whenever adaptation or								
	further development of algorithms and systems is necessary.								
	This module complements MA-INF 4112 and can be taken								
	before or after								
Soft skills	Communicativ	•			_				
	discussions in		, .		_		ept		
Q , , ,	and formulate								
Contents	Types of learning and analysis tasks, most important								
	non-parametric and parametric methods for supervised learning (e.g., decision trees, rules, linear methods, neural networks,								
	` = '								
	_	hbourhood methods, kernel methods, probabilistic roaches), reinforcement learning, evaluation and learning							
	theory.	CIIIIOI CCIIIC	110 1001	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Cvaraaoio	m and rearming	•		
Prerequisites	Required:								
- 1	MA-INF 4102 - Intelligent Learning and Analysis Systems has								
	not been passed.								
	Recommended	•							
	Prior knowledg		bility	theor	v. linear a	algebra, artifici	al		
	intelligence, in			•	, ,	· ,			
	Teaching forms		- Group		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	Written exam		,, ~	macp			ded)		
Study achievements	Successful exer	rcise partic	ipatio	$\overline{\mathrm{n}}$		(not gra			
Forms of media	Lectures, exerc				S	(1100 810			
_ 51112	- Tom Mitchel					Hill, 1997			
Literature									
Diveracule	- Ian Witten, Eibe Frank, Data Mining, Morgan 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	Prof. Dr. Stefan Wrobel						
coordinator								
Lecturer(s)	Prof. Dr. Wrobel							
Classification	Programme							
	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	-						
	_	,				UIIC		
	module, students will be capable of choosing appropriate methods and systems for particular pattern discovery							
	applications and use them to arrive at convincing results, and							
	will know where to start whenever adaptation or further							
	development of algorithms and systems is necessary. This							
	module complements MA-INF 4111 and can be taken before or							
	after that mod							
Soft skills	Communicative skills (oral and written presentation of solutions,							
	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 learning and analysis tasks, scalability techniques,							
	descriptive data mining methods, association rules, subgroups,							
	clustering, pre- and postprocessing, data storage (data							
	warehouses, OLAP), special data types (spatial, network, text,							
	multimedia da	ta), interact	ive and vi	sual syste	ems.			
Prerequisites	Required:	T . 111	т.					
	MA-INF 4102 - Intelligent Learning and Analysis Systems has							
	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				,-	$\frac{\operatorname{ded}}{\operatorname{ded}}$		
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, I			_	g: Concepts an	d		
	Techniques, M	organ Kaufi	nann, 200	0				

Module MA-INF 4113	Cognitive F	Robotics						
	C	D4:	Th					
Workload	Credit points 6 CP	Duration 1 gamagter	Freque	=				
180 h	0 0							
Module	Prof. Dr. Svei	Prof. Dr. Sven Behnke						
coordinator	D C D C	D 1 1						
Lecturer(s)	Prof. Dr. Svei	n Behnke	l					
Classification	Programme	, G:	Mode	Semest				
	M. Sc. Compu		Optiona	I				
Technical skills					es of the intellig	gent		
	systems track.			_	-			
	· · · · · · · · · · · · · · · · · · ·			J, .	perception, and	d		
	action-plannin	g in complex	environn	nents.				
	This module of	complements	MA-INF	4114 and	can be taken			
	before or after	before or after that module.						
Soft skills	Communicativ	ve skills (oral	and writt	en presen	tation of solut	ions,		
	discussions in small teams), self competences (ability t							
	and formulate criticism, ability to analyze problems)							
Contents	Probabilistic a	approaches to	state est	imation (Bayes Filters,			
	Kalman Filter, Particle Filter), motion models, sensor models,							
	self-localization, mapping with known poses, simultaneous							
	mapping and localization (SLAM), iterated closest-point							
	matching, path planning, place- and person recognition, object							
	recognition.							
Prerequisites	Required:							
	MA-INF 4101	- Theory of	Sensorimo	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	30 T / 75 S	3.5		
	T = face-to-face teaching; S = independent study							
Exam achievements	Written exam					ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
	• S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics.							
	MIT Press, 2005.							
T:4	• B. Siciliano,	O. Khatib (Eds.): Spi	ringer Hai	ndbook of			
Literature	Robotics, 2008		. –					
	• R. Szeliski:	Computer V	ision: Alg	orithms a	nd Application	ıs,		
	Springer 2010.							

Module	Robot Lear	ning						
MA-INF 4114	G 11.	ъ.,						
Workload	Credit points	Duration	Freque	-				
180 h	6 CP	1 semester	every y	rear				
Module	Prof. Dr. Sver	n Behnke						
coordinator								
Lecturer(s)		Prof. Dr. Sven Behnke, Dr. Nils Goerke						
Classification	Programme	~ .	Mode	Semest				
	M. Sc. Compu		Optiona					
Technical skills				-	es of the intellig	_		
	systems track.							
		assist humans in situations of daily life is a fascinating challenge						
		or machine learning. The lecture covers key ingredients for a						
	_	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						
	demonstration	demonstrations and imitation learning, and interactive learning.						
	This module c	This module complements MA-INF 4113 and can be taken						
	before or after that module.							
Soft skills	Communicativ	e skills (oral	and writt	ten presen	tation of solut	ions,		
	discussions in	small teams)	, self com	petences	(ability to acce	ept		
	and formulate	criticism, ab	ility to ar	nalyze pro	blems)			
Contents	Reinforcement	learning, M	arkov dec	ision proc	esses, dynamic	;		
	programming,	Monte Carlo	methods	s, tempora	al-difference			
	methods, func	tion approxi	nation, lie	ear quadr	atic regulation	,		
	differential dyn	namic progra	mming, p	artially o	bservable MDI	$P_{\mathbf{S}}$,		
	policy gradien	t methods, in	verse rein	nforcemen	t learning,			
	imitation learn	ning, learning	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 = index	endent st	udv			
Exam achievements	Oral exam	- 01	r			ded)		
Study achievements	Successful exer	rcise particip	ation		(not gra			
Forms of media					, 5			
	• R. Sutton ar	nd A. Barto:	Reinforce	ement Lea	rning, MIT-Pr	ess,		
	1998.				<i>5</i> /	,		
Literature	• O. Sigaud and J. Peters (Eds.): From Motor Learning to							
	Interaction Learning in Robots. Springer, 2010.							

Module	Artificial Li	fe						
MA-INF 4201			1					
Workload	Credit points	Duration	Freque	-				
180 h	6 CP	1 semester	every y	rear				
Module	Prof. Dr. Sven	n Behnke						
coordinator								
Lecturer(s)	Prof. Dr. Sven	n Behnke, Dr.						
Classification	Programme	~ .	Mode	Semest	ter			
	M. Sc. Compu		Optiona					
Technical skills	Detailed under	0		•	* *			
	principles of a		_		_	the		
		current state of research in the field of artificial life Capability to identify the state of the art in artificial life, and to						
Soft skills		·			,			
	present and de							
	front of a grou	=	. Critica.	l discussio	on of the result	s of		
	the homework.							
Contents		Foundations of artificial life, cellular automata, Conway's "Gan of Life"; mechanisms for structural development; foundations of the control						
	· · · · · · · · · · · · · · · · · · ·			-	,	s of		
	nonlinear dyna		,					
	evolutionary m	_						
	learning, artific		-	_				
	self-organising		_	-	, and swarm			
D 111	intelligence, pa	article swarm	optimiza	ttion.				
Prerequisites	none			1 / 1	*** 11 1511	GD		
.	Teaching forma	at Gro	oup size	h/week	Workload[h]	CP		
Format	Lecture			$\begin{array}{c c} 2 \\ 2 \end{array}$	30 T / 45 S	2.5		
	Exercises			l	30 T / 75 S	3.5		
	T = face-to-face	ce teaching; S	S = indep	endent st				
Exam achievements	Written exam				(gra	ided)		
Study achievements	Successful exer				(not gra			
Forms of media	Pencil and pap					ercise		
	group, implem		nall prog	rams, use	e of simple			
	simulation too							
	• Christoph A				*			
	Electronic Library of Science, TELOS, Springer-Verlag							
	• Eric Bonabeau, Marco Dorigo, Guy Theraulaz: Swarm							
	Intelligence: From Natural to Artificial Systems, Oxford							
Literature	University Pre	ss, Santa Fe I	Institute	Studies in	n the Science o	of		
Liveravare	Complexity.							
	• Andrzej Osy		·	_	_			
	Multicriteria I				-			
	Soft Computin	ng, Physica-Ve	erlag, A	Springer-	Verlag Compar	ıy,		
	Heidelberg							

Module	Autonomous	Mobile	Systems				
MA-INF 4203							
Workload		Duration	Freque	ncy			
180 h	6 CP	1 semeste	every y	ear			
Module	Prof. Dr. Sven	Behnke					
coordinator							
Lecturer(s)	Dr. Dirk Schulz	z, Prof. Dr		nke			
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Comput		Optiona				
Technical skills	Profound know	_	_			cture	
		and function of learning, autonomous, mobile systems;					
	_	Knowledge of the computational, mathematical, and technical					
	_	equirements for the design of autonomous systems for specific					
		pplications and for specific functional environments					
Soft skills		The students will be capable to assess applications for					
		utonomous mobile systems. They will be capable to identify					
		that part of the applications might be improved by using state					
		of the art developments. The student will learn how to plan and					
C 1 1		implement a software project in small working groups. Requirements for the implementation of autonomous mobile					
Contents	systems, e.g. fo	-					
	SLAM-methods	-	· ,		· ,		
	methods for act	-	_	_		າຕ	
	paradigms for s	_	_	1115011 01 (- 8	
Prerequisites	Recommended:	promise app	110000101101				
1	all of the follow	ing:					
	MA-INF 4101 -	_	Sensorim	otor Syste	ems		
	MA-INF 4113 -	-		v			
	Teaching format		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-fac	e teaching;	S = indep	endent st	udy	•	
Exam achievements	Oral exam					ded)	
Study achievements	Successful exerc	cise partici	oation		(not gra		
Forms of media					, –		
	• J. Buchli: Mobile Robots: Moving Intelligence, Published by						
	Advanced Robo	otic System	s and Pro	Literatur	Verlag		
Literature	• Sebastian Th		_	d, Dieter	Fox: Probabili	stic	
Diterature	Robotics, MIT						
	Howie Choset	t 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		The students will be capable to propose several paradigms from						
		neural networks that are capable to solve a given task. They can						
	_	liscuss 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	Dynamicall	Dynamically Reconfigurable Systems						
Workload	Credit points	Duration	Freque	ncv				
180 h	6 CP	1 semeste	_	t every 2	vears			
Module	Prof. Dr. Joac		I		V			
coordinator								
Lecturer(s)	Prof. Dr. Joac	chim K. An	lauf					
GI 10 II	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Science	Optiona	1 2.				
Technical skills	Knowledge of	Knowledge of the most important FPGA architectures, ability						
	to select appro	o select appropriate FPGAs for a given application, overview of						
	programming	programming tools						
Soft skills	Communicativ	Communicative skills (oral and written presentation of						
	solutions), soc	solutions), social skills (ability to solve problems in small teams						
	discussions of	solution co	ncepts) self	competer	nces (ability to)		
	accept and for	mulate crit	icism, abili	ty to anal	lyze problems)			
Contents	Architecture o	f FPGAs,	Configurabl	e Logic B	Blocks, Wiring			
	/ *		· ·		tion Language	s,		
	Synthesis, Tec	00	11 0/		oute, FPGA			
	Computing, Pa	artial Reco	nfigurabilit	y				
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	S = indep	endent st	tudy			
Exam achievements	Oral exam				(gra	ded)		
Study achievements	Successful exe	rcise partic	pation		(not gra	ded)		
Forms of media								
Literature	Current resear	ch papers	and technic	al 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 every semester				
120 h	Prof. Dr. Svei		every se	emester			
Module	Prof. Dr. Svei	і Беппке					
coordinator	Doof Do Care	Dobreleo De	of Dn Io	a alaissa IV	Aralouf		
Lecturer(s)	Prof. Dr. Sver Dr. Nils Goerl	,	01. D1. JC	aciiiii K	. Amaui,		
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	
	as well as in a						
Soft skills	Self-competen	`	_		,		
	self-study), communication skills (preparation and clear didact						
	_		,		sion, structured		
	writing of sem	inar report),	social ski	lls (abilit	y to formulate	and	
	_	accept criticism, critical examination of research results).					
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 Learning						
	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, Pre	entice Hall, 2	UU3.				

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. Stef	an Wrobel					
	Programme Mode Semester						
Classification	M. Sc. Computer Science		Optiona				
Technical skills	•		-		zed topics in th	ie	
	area of machin	-	0	•	*		
		_			literature, pres	ent	
	_	t to others and discuss it with a knowledgeable scientific					
	auditorium. L	earn how to	scientifica	lly preser	nt prior work by	У	
	others, in writ	others, in writing and in presentations.					
Soft skills	Communicativ	Communicative skills (preparing and presenting talks, written					
	presentation o	presentation of contents in a longer document), self competences					
	(time manager	ment with l	ong-rangin	g deadline	es, ability to ac	cept	
	and formulate criticism, ability to analyse, creativity).						
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	nts Duration Frequency 1 semester at least every 2 years					
Module	Prof. Dr. Joac	_ = =======			every 2	years	
coordinator	1 101. D1. 30ac	JIIIII IX. A	mauı	_			
	Duef Du Jees	Prof. Dr. Joachim K. Anlauf					
Lecturer(s)		min K. A					
Classification	Programme	, a .		Mode	Semest		
	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	and formulate criticism, discussions 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	gnitive Ro	botics				
MA-INF 4211							
Workload	Credit points	Duration	Frequency				
120 h	4 CP	1 semester every semester					
Module	Prof. Dr. Sver	ı Behnke					
coordinator							
Lecturer(s)	Prof. Dr. Sver	Behnke, D	. Nils Go	erke			
Classification	Programme		\mathbf{Mode}	Semes	Semester		
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 paper			_	_		
	in a seminar re	_					
Soft skills	Self-competence		nagement	literatur	e search,		
	_	self-study), communication skills (preparation and clear didactic					
	- / :	presentation of research talk, scientific discussion, structured					
	_		*		*		
	_	writing of seminar report), social skills (ability to formulate and accept criticism, critical examination of research results).					
Contents	_	Current research papers from conferences and journals in the					
	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	Data Science	e and Rig	Data					
MA-INF 4212	Data Science	and Dig	Data					
Workload	Credit points	Duration	Frequen	CV				
180 h	6 CP	1 semester	every yes					
Module	Prof. Dr. Stefan		cvery yea					
coordinator	Tion Di. Secian	WIODCI						
Lecturer(s)	Dr. Tamas Horv	ath PD Dr	Michael V	lock				
` ,	Programme		/Iode	Semester				
Classification	M. Sc. Compute		Optional	3. or 4.				
Technical skills	Participants acq		-		nt aspects of big	·		
	data analytics ar	-	_					
	and big data dat		_					
	structured and u		_		- '			
	computer because	se it has enor	mous size	and/or con	tinuously arrive	es		
	with such a high	rate that red	quires imm	nediate pro	cessing.			
Soft skills	Communicative	skills (oral ar	d written	presentation	on of solutions,			
	discussions in tea							
	criticism, ability				-	end"		
	, .	ask), social skills (effective team work and project planning).						
Contents	The module is o		ear, each	time conce	ntrating on one	or		
	more specific iss	ues, such as						
	- architectures a	nd procols for	r big data	systems,				
	- distributed bat	ch and strear	n processi	ng systems	,			
	- non-standard d	latabases for	big data,					
	- databases for s	tructured dat	a,					
	- similarity searc	eh,						
	- synopses for m	assive data,						
	- classical data r	nining tasks f	or massive	e data and,	or data streams	з,		
	- mining massive							
	- applications.							
Prerequisites	Recommended:							
	All of the follow:	_						
	MA-INF 4111 –	Intelligent Le	earning an	d Analysis	Systems: Mach	ine		
	Learning							
	MA-INF 4112 –	9		d Analysis	Systems: Data			
	Mining and Kno							
	Teaching forma	t Gı	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 =	= independ	dent study				
Exam achievements	Written exam					aded)		
Study achievements	Successful exerci				(not gra	aded)		
Forms of media	lectures, exercise			1	11			
	- N. Marz and J. Warren: Big Data. Principles and best practices of							
	scalable realtime data systems. Manning Pubn, 2014.							
	- T. White: Hadoop The Definitive Guide. O'REILLY, 2012.							
Literature	- A. Rajaraman	and J.D. Ulli	nan.: Min	ing of Mass	sive Datasets.			
	Cambridge Univ	ersity Press,	2011.					
	- G. Cormode, N	I. Garofalaki	s, P.J. Haa	as, and C.	Jermaine: Synor	oses		
	for Massive Data							
	Foundations and	Trends in D	atabases 4	(1-3): 1-29	4 (2012).			

Module MA-INF 4213	Seminar Hu	ımanoid I	Robots						
Workload	Credit points	Duration	Frequer	ıcy					
120 h	4 CP	4 CP 1 semester every semester							
Module	Prof. Dr. Mar	en Bennewi	tz						
coordinator									
Lecturer(s)	Prof. Dr. Mar	en Bennewi	tz						
Classification	Programme		Mode	Semes	ter				
Classification	M. Sc. Compu	ter Science	Optional	2.					
Technical skills	Knowledge in	advanced to	pics in the	area of h	numanoid robo	tics,			
	such as enviro	nment perce	eption, stat	e estimat	tion, navigation	n, or			
	motion planni	ng. Ability	to understa	and new r	research results	s of			
	scientific pape	rs and to pr	esent them	in a talk	as well as in	a			
	self-written su	mmary.							
Soft skills	Self-competen	ces (time m	anagement	literatur	re search,				
	self-study), co	mmunicatio	n skills (pr	eparation	of the talk, cl	ear			
	didactic preser	didactic presentation of techniques and experimental results, scientific discussion, structured writing of summary), social skills							
	scientific discu								
	(ability to form	nulate and	ccept criti	cism, crit	ical examinati	on of			
	algorithms and		_						
Contents	Current resear	Current research papers from conferences and journals in the							
	field of human	oid robotics	covering f	undamen	tal techniques	and			
	applications.								
Prerequisites	Recommended	:							
	At least 1 of t	he following	:						
	MA-INF 4215	– Humanoi	d Robotics						
	MA-INF 4113	- Cognitive	Robotics						
.	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	tudv	'			
Exam achievements	Oral presentat					aded)			
Study achievements	1	,	1		(not gra				
Forms of media					, ,				
	- S. Thrun, W	. Burgard a	nd D. Fox:	Probabil	listic Robotics.				
	- S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press								
T.,	- B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics								
Literature	- K. Harada, E. Yoshida, K. Yokoi (Eds.), Motion Planning for								
	Humanoid Ro	,	`	,,	0				
	- Selected pap								
	- selected pap	c18.							

Module MA-INF 4214	Lab Human	oid Robots	5						
Workload	Credit points	Duration	Freque	ncv					
270 h	9 CP	1 semester		semester					
Module	Prof. Dr. Mar								
coordinator	Tion Di. Wai	CII BOIIIIC W 102	•						
Lecturer(s)	Prof. Dr. Mar	en Bennewitz	<u> </u>						
	Programme	Dolling Wite	Mode	Semes	ster				
Classification	M. Sc. Compu	iter Science	Optiona		3001				
Technical skills	_				in the design a	and			
Teominear simils	_		-	_	on, environmen				
	_		,		ing techniques				
	_			_	cipants analyze				
				_					
	problem, realize a solution, and perform an experimental evaluation.								
Soft skills	Self-competen	ces (time mar	nagement	, goal-ori	iented work, ab	oility			
	to analyze pro	`	_	, .	,	·			
		solutions), communication skills (collaboration in small teams							
	/ /		`		itical examinat	,			
	of implementa	_		,					
Contents	Robot middle	Robot middleware (ROS), perception, state estimation,							
	environment r	epresentation	s, naviga	tion, and	motion planni	ing			
	for humanoid	robots.							
Prerequisites	Recommended	:							
	At least 1 of t	he following:							
	MA-INF 4215	- Humanoid	Robotics	3					
	MA-INF 4113	- Cognitive 1	Robotics						
	Teaching form		up size	h/week	Workload[h]	CP			
Format	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching: S	S = inder	pendent s	study	'			
Exam achievements	Oral presentat					aded)			
Study achievements	P	, , , , , , , , , , , , , , , , , , , ,	· F · · ·		(not gra				
Forms of media					, 3				
	- S. Thrun, W	. Burgard and	d D. Fox	: Probab	ilistic Robotics	•			
	- S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press								
T.,	- B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics								
Literature	- K. Harada, E. Yoshida, K. Yokoi (Eds.), Motion Planning for Humanoid Robots, Springer								
		,							
	- Selected papers.								

Module	Humanoid	Robotics					
MA-INF 4215							
Workload	Credit points	Duration	Frequer	ncy			
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	2-4.			
Technical skills	This lecture co	overs techniq	ues for hu	manoid r	obots 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	n with least s	squares, 3	D enviror	nment		
	representation	epresentations, self-localization with particle filters, footstep					
	planning, inve	rse kinematic	es, whole-l	oody mot	ion planning w	$_{ m vith}$	
	rapidly explor	ing random t	rees, stati	stical tes	ting.		
Prerequisites	Recommended	:					
	MA-INF 4113	- Cognitive	Robotics				
	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	tudy		
Exam achievements	Oral exam					ded)	
Study achievements	Successful exe	rcise particip	ation		(not gra	$\overline{\mathrm{ded}}$	
Forms of media					, -		
	• S. Thrun, W	7. 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, İ	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	1 semeste	er every y	rear				
Module	Dr. Holger Frö	öhlich						
coordinator								
Lecturer(s)	Dr. Holger Frö	öhlich	T					
Classification	Programme M. Sa. Compu	tor Sajonao	Mode	Semest	ter			
Technical skills	M. Sc. Compu		_		al data mining	and		
recimieat skins	- understanding and knowledge of fundamental data mining and machine learning methods							
	- 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		
	to formulate p			с аррпсас	ion problems a	iia		
	- practical skill			ly implem	ent solutions			
	- social skills:	· ·	-	-				
Contents	This lecture gi							
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 partially implement them. More detailed, the							
	following topics are covered in the context of their application in							
	bioinformatics:							
	- Short introduction to Bioinformatics and Biomedicine							
	- Statistical Basics: Probability distributions and Bayesian inference, statistical hypothesis testing, linear models, logistic							
					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			

	C • 1M	1 · T		• 1/4		· /1 T·C
Module MA-INF 4217	Seminar Ma Sciences	acnine L	ear	ning M	etnods	in the Life
		D4:	.	T		
Workload 120 h	Credit points 4 CP	Duration 1 semes		Frequer	-	
Module	Dr. Holger Frö		ter	every y	ear	
coordinator	Dr. Holger Fre)1111C11				
Lecturer(s)	Dr. Holger Frö	ihlich				
. ,	Programme			Mode	Semest	ter
Classification	M. Sc. Compu	ter Scienc		Optional	4.	
Technical skills	- understandin	g and kno	owle	dge of m	achine lea	arning methods e.g. biomedicine
Soft skills						of a defined topic
Soft Skills				-		-
	_		-	-		literature for a nalyze scientific
	- social skills: students and the		disc	uss a sci	entific top	oic with other
Contents	sciences, including discuss a variety	Machine learning techniques play a crucial role in modern life sciences, including biomedicine. The goal of this seminar is to discuss a variety of machine learning techniques in the context of their application to solve real-world problems in biomedicine.				
	Topics will be	selected f	rom	the follo	wing area	as:
	- Ensemble lea				J	
	- Survival and		rogre	ession m	odels	
	- Bayesian Net		- 0			
		ocesses, e	.g. (Gaussian	Proceses	, Dirichlet Process
	- MCMC meth	ods				
	- Deep learning methods, e.g. DNNs, CNNs, Deep Belief Networks					
	- feature select	ion and n	on-l	inear em	bedding 1	methods
	- multi-modal				_	
	Attendees will be asked to perform research about their topic in a self-responsible manner.					
Prerequisites	Recommended: MA-INF 4216	: – Data M		g and M	achine Le	earning Methods in
	Bioinformatics				1- / 1	W1-1 1011 CD
Format	Teaching forma Seminar	at	Gro	up size	h/week	Workload[h] CP 30 T / 90 S 4
		, 1.		ı		, ,
D	T = face-to-fac				endent st	
Exam achievements	Oral presentat	ion, writt	en re	eport		(graded) (not graded)
Study achievements Forms of media	powerpoint					(not graded)
Literature	selected journa	al and con	fere	ice nano	rq	
Literature	between Journa	a and con	1016	ice pape	10	

Module	Lab Modeli	ng and Si	nulatio	n			
MA-INF 4218		O					
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste:	r every year				
Module	Prof. Dr. And	reas Weber	'				
coordinator							
Lecturer(s)	Prof. Dr. And	reas Weber,	Prof. Dr	. Holger	Fröhlich		
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2.			
Technical skills	- ability to des	scribe a syst	em via a	model			
		nduct a simu	lation stu	ıdy, visua	lize and interpr	et	
	its results						
	- ability to im		_	_			
	·	MATLAB, R or via usage of some other software					
Soft skills	- ability to cor				-		
	learned methods together with a team of other students						
	- ability to pre	esent and ex	olain resu	lts and to	o defend design		
	decisions						
Contents	Simulation and	d analysis of	complex	systems	that arise, for		
	example, in sy	stems biolog	y. Covere	ed modell	ing approaches	are:	
	- Boolean Net	works					
	- ODEs						
Prerequisites	Recommended	:					
	MA-INF 4217	– Seminar I	Machine I	Learning I	Methods in the	Life	
	Sciences						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
roimat	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	powerpoint						
	- U. Alon, An	Introduction	to Syste	ms Biolog	gy, CRC Press,	$2\overline{007}$	
Literature	- E.S. Allman	& J.A. Rho	des "Matl	hematical	Models in Biol	ogy"	
	Cambr.Univ.P						

Module	Lab Paralle	l Comput	ing for I	Mobile 1	Robotics		
MA-INF 4226							
Workload	Credit points	Duration	Freque	ncy			
270 h	9 CP	1 semeste	every y	year			
Module	Prof. Dr. Mar	en Bennewi	\mathbf{z}				
coordinator							
Lecturer(s)	Prof. Dr. Mar	en Bennewi	\mathbf{Z}				
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Optiona	d 2.			
Technical skills	Students will 1	nake praction	al experie	ence with	the design and		
	implementatio	implementation of parallelized algorithms in the context of					
	motion planni	motion planning and navigation.					
Soft skills	Ability to properly present and defend design decisions, to						
	prepare readal	prepare readable documentation of software; skills in					
	constructively	collaboratir	g with ot	hers in sr	nall teams over	a	
	longer period	of time; abil	ity 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 = indej	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ided)	
Study achievements		<u> </u>			(not gra	ded	
Forms of media							
Literature							

Module MA-INF 4228	Foundations	s of Data S	science			
Workload	Credit points	Duration	Freque	ency		
270 h	9 CP	1 semester	every	year		
Module	Prof. Dr. Emi	manuel Mülle	r			
coordinator						
Lecturer(s)	Prof. Dr. Emi	manuel Mülle	r, Dr. M	Iichael Nü	isken	
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.	
Technical skills	Knowledge: Po	eculiarities of	high di	mensional	spaces in geom	netry
	and probabilit	ies. Singular	vector d	ecomposi	tion. Basics in	
	machine learni	ing and cluste	ering.			
	Skills: Unders	tanding of ma	athemati	ical tools.		
Soft skills					oblems and abi	lity
	to assess similar	ar methods.		_		-
Contents	Data science a	Data science aims at making sense of big data. To that end,				
	various tools h	nave to be un	derstood	l for helpi	ng in analyzing	the
	arising structu	ires.				
	Often data comes as a collection of vectors with a large number of components. To understand their common structure is the					nber
	first main objective of understanding the data. The geometry					
	and the linear			_	_	J
		_			ensional space t	urns
	out to be ofter				_	
		_			ces when worki	ng
	with such data	_		_		Ü
	singular vector	r decompositi	on from	linear alg	gebra and	
	supervised and	d unsupervise	d machi	ne learnin	ng. If time perm	nits,
	we also consid	er random gr	aphs, wh	nich are tl	he second most	used
	model for real	world pheno	mena.			
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
	T = face-to-fa	ce teaching; S	S = inde	pendent s	study	
Exam achievements	Schriftliche Pr					ided)
Study achievements	Erfolgreiche Ü	bungsteilnah	me		(not gra	ided)
Forms of media						-
Litopotuno	Avrim Blum,	John Hopcrof	t, and R	avindran	Kannan (2018-	+).
Literature	Foundations o	f Data Science	e.			

Module MA-INF 4229	Pattern Rec	cognition	(1)				
Workload	Credit points	Duration	Freque	ncy			
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Christ	tian Bauckha					
coordinator							
Lecturer(s)	Prof. Dr. Christ	tian Bauckha	age				
Cl. 10 11	Programme		Mode	Semester			
Classification	M. Sc. Compute	er Science	Optional	2.			
Technical skills	Upon completio	n, students s	should be a	able to			
	• devise mathen clustering, and continuing tion	classification			•		
	optimization• implement bas classification• implement bas						
Soft skills		tudents will learn about the mathematical and algorithmic					
	foundations of n				~	l	
		earn about basic and advanced mathematical models in this area, how o implement them on their own, and how to put them into practice.					
Contents	• fundamental concepts, prerequisites, and procedures in pattern						
	recognition						
	 basic and advanced concepts in linear algebra basic and advanced concepts in probability theory and statistics 						
	• least squares t	-		ting			
	• maximum like		-				
	• maximum a-po		-				
	Bayesian infer			1 /1	17C 1: .		
	• fundamental a	-	_	ry and the	VC dimension		
	• the curse of di						
	methods and aGaussian mixt	_	or data ciu	stering			
	• the method of		ultiplions s	and the KK	T conditions		
	• quadratic and		-		1 conditions		
	• algorithms for						
	• support vector		. ориннаа	1011			
	• the kernel tric						
	• neural network						
	• Hebbian learn						
Prerequisites	Recommended						
1	Students should		ng knowled	lge in linear	algebra, probab	oility	
	theory, and stat					v	
	Teaching forma		Group size		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	= indeper	dent study			
Exam achievements	Schriftliche Prüt		P		(gra	aded)	
Study achievements	Erfolgreiche Üb	-	ne		(not gra		
Forms of media	• lecture slides a			ne	, 0		
	• lecture notes v	with program	nming exar	nples are m	ade available on	line	
	Bishop, "Pattern						
Literature	Duda, Stork, Ha	_					
					maina Alma:+1-	a"	
	MacKay, "Inform	nation Theo	ry, inieren	ce, and Lea	rning Algorithm	S	

Module	Advanced L	earning Sy	zstems				
MA-INF 4302	110.0011000 1	~.	, 200112				
Workload	Credit points	Duration	Freque	ncv			
180 h	6 CP	1 semester	every y	=			
Module	Prof. Dr. Stefa						
coordinator		,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,					
Lecturer(s)	Prof. Dr. Stefa	an Wrobel. I	r. Thom:	as Gärtne	er		
()	Programme	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Mode	Semest			
Classification	M. Sc. Compu	ter Science	Optional	l 2. or 3	3.		
Technical skills	Participants sp particular class necessary know construct their research fronti-	pecialize and s of learning wledge to impose own within	require in algorithm prove exist the given	n-depth kins, they a ting algor	cquire the rithms and		
Soft skills	communication	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.					
Contents	one or more sp	The module is offered every year, each time concentrating on one or more specific algorithm classes, e.g. • kernel machines					
	 Refrie machines neural networks probabilistic and statistical learning approaches logic-based learning approaches reinforcement learning Recommended: all of the following: 						
Prerequisites							
	MA-INF 4111 – Intelligent Learning and Analysis Systems: Machine Learning						
	MA-INF 4112 Data Mining a	_	_		lysis Systems:		
	Teaching forma	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-face	ce teaching:	S = inder	endent st	andv	•	
Exam achievements	Written exam	<u> </u>				ded)	
Study achievements		cise particip	ation				
Forms of media					(1100 810		
Literature	 B. Schoelkop Press, 2002, C. John Shawe- Pattern Analy Christopher Learning, The David MacK Algorithms, 20 	Successful exercise participation (not graded) lectures, exercises, software systems 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 Bishop, Pattern Recognition and Machine Learning, The University of Edinburgh, 2006 David MacKay, Information Theory, Inference, and Learning Algorithms, 2003 Richard Duda, Peter Hart, David Stork, Pattern					

Module	Learning fro	om Non	-Sta	ndard	Data		
MA-INF 4303							
Workload	Credit points	Duration		Freque	-		
180 h	6 CP 1 semester every year						
Module	Prof. Dr. Stefa	an Wrobe	el				
coordinator							
Lecturer(s)	Prof. Dr. Stefa	an Wrobe					
Classification	Programme			Mode	Semest		
	M. Sc. Compu			Optiona			,
Technical skills	Participants de	_		_			h
	respect to one	-					4
	non-tabular da	,			_		ant
	in many applic specialized alg						œ
	pre- and postp				_		_
	participants in	_	-				
	necessary socia				,	-	UIIC
	work and proje						re
	projects to oth	-		arra rear	11011 00]	prosent sortwa	
Soft skills	Communicative skills (oral and written presentation of solutions,						ions.
		discussions in teams), self-competences (ability to accept and					
	formulate criticism, ability to analyse, creativity in the context						
	of an "open end" task)						
Contents	The module w	ill offered	evei	ry year,	concentra	ting on one	
	particular non-						t
	Mining, Multin	media Mi	ning,	Graph	Mining. I	Learning from	
	structured dat	a, Spatial	l Dat	a Minin	g		
Prerequisites	Recommended	:					
	all of the follow	wing:					
	MA-INF 4111	- Intellig	ent I	Learning	and Anal	lysis Systems:	
	Machine Learr	$_{ m ning}$					
	MA-INF 4112	- Intellig	ent I	Learning	and Anal	lysis Systems:	
	Data Mining a	nd Know	ledge	e Discov	ery		
	Teaching forma	at	Gro	up 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	= indep	endent st	udy	
Exam achievements	Written exam					(gra	ded)
Study achievements	Successful exer	rcise parti	icipa	tion		(not gra	ded)
Forms of media	lectures, exerc	ises, softw	vare	systems.			
	• Gennady An	drienko,	Nata	lia Andr	ienko, Ex	ploratory Ana	lysis
	of Spatial and	Tempora	l Da	ta, Sprin	ger, 2006		
	• Diane J. Coo	ok, Lawre	ence l	B. Holde	r, Mining	Graph Data,	
	Wiley & Sons,	2006					
Literature	• Saso Dzerosl		Lavra	ac, Relat	ional Dat	a Mining,	
	Springer, 2001						
	• Sholom M. V			-	-		
	Damerau, Tex	_				or Analyzing	
	Unstructured 1	Informati	on, S	pringer,	2004		

Module	Lab Cognit	ive Roboti	cs				
MA-INF 4304							
Workload	Credit points						
270 h	9 CP						
Module	Prof. Dr. Svei	n Behnke					
coordinator							
Lecturer(s)	Prof. Dr. Svei	n Behnke	Γ				
Classification	Programme		Mode	Seme			
	M. Sc. Compu		Optiona				
Technical skills	Participants a		_		_	-	
		_	-		of perception a	and	
	control algorit		_	-			
	group, they ar				e-of-the-art		
G 0: 1:11	solution, and				• 4 1 1 1	•1•4	
Soft skills	_	*	_	. –	iented work, ab	omty	
	to analyze pro		_		, .	nd	
		communication skills (Work together in small teams, oral and written presentation of solutions, critical examination of					
	implementations)						
Contents	Robot middleware (ROS), simultaneous localization and						
Contents		mapping (SLAM), 3D representations of objects and					
	,	environments, object detection and recognition, person detection					
		-		_	ning and contro		
	mobile manipi					,	
Prerequisites	Recommended	:					
	At least 1 of t	he following:					
	MA-INF 4113	- Cognitive	Robotics				
	MA-INF 4114	- Robot Lea	rning				
T	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 = indep	endent s	study		
Exam achievements	Oral presentat					aded)	
Study achievements					(not gra	aded)	
Forms of media							
	,	0	nd D. Fox	: Probab	oilistic Robotics	s	
	MIT Press, 20						
Literature	• B. Siciliano,	,	Eds.): Spi	ringer Ha	andbook of		
	Robotics, 2008						
	• Selected rese	earch papers.					

Module MA-INF 4306	Lab Develor	_		ation o	f Data Mini	ng		
Workload	Credit points	Duration	Frequency					
270 h	9 CP 1 semester every year Prof. Dr. Stefan Wrobel							
Module	Prof. Dr. Stef	an Wrobel						
coordinator	D C D C C							
Lecturer(s)	Prof. Dr. Stef	an Wrobel						
Classification	Programme		Mode	Seme	ster			
	M. Sc. Compu		Optional		.1			
Technical skills			-	_	the construction			
	_	_			ms for machine			
		_			work with exi	sting		
	state-of-the-ar	-						
		-	g them to	r the req	quirements of the	neir		
	particular task							
Soft skills		Communicative skills (appropriate oral presentation and written documentation of project results), social skills (ability to work in						
					, -	rk in		
	teams), self-co	• (,	0			
	long-range goals under limited ressources, ability to wor							
	pressure, ability to accept/formulate ciriticsm)							
Contents		-			lysis. Common			
	open source frameworks for the construction of data analysis							
	systems, specialized statistical packages. Pre-processing tools.							
	Mathematical libraries for numerical computation. Search and							
	optimization methods. User interfaces and visualization for							
	analysis systems. Data analysis algorithms for embedded and							
	distributed sys	stems. Ubiqu	itous disc	overy sy	stems.			
Prerequisites	Recommended							
	At least 1 of t	he following:						
	MA-INF 4111	- Intelligent	Learning	and Ana	alysis Systems:			
	Machine Learn	ning						
	MA-INF 4112	- Intelligent	Learning	and Ana	alysis Systems:			
	Data Mining a	_	_					
	Teaching forms			h/week	Workload[h]	CP		
Format	Lab	323	8	4	60 T / 210 S	9		
	T = face-to-fa	co tooching:			,	1		
Even eshiorement:				endent S		aded)		
Exam achievements	Oral presentat	Jon, written	report		(0			
Study achievements	Computer C-f	turana Daa	oontstis-	Doggazza	(not gra	idea)		
Forms of media	Computer Sof	,				£ 41		
Literature			pe annou	inced tov	wards the end of	or the		
	previous semester.							

Module MA-INF 4307	Lab Field P	rogramm	able Ga	te Arra	ys		
Workload	Credit points	Duration	Freque	ancv			
270 h	9 CP	1 semeste					
Module		Prof. Dr. Joachim K. Anlauf					
coordinator	1101. 11. 0000	AIIIII 11. 21II	aar				
Lecturer(s)	Prof. Dr. Joac	him K. An	auf				
	Programme		Mode	Seme	ster		
Classification	M. Sc. Computer Science		Option	al 2. or	3.		
Technical skills	•		_		ts in VHDL and	<u>l</u>	
	_		0		ets, knowledge		
	, .	he design path from the idea to a realized circuit implemented					
	in an FPGA (f				-		
Soft skills	Communicativ	e skills (or	l and wri	tten prese	entation of resul	lts),	
	social skills (ability to cooperate in small teams, discussions of					of	
	solution concepts) self competences (ability to accept and						
	formulate criti	cism, abilit	y to analy	ze and fir	nd practical		
	solutions to pr	oblems)					
Contents	VHDL for Har	dware Des	ription, S	imulation	, and Synthesis	,	
	SystemC for H	Iardware D	escription	, Simulati	on, and Synthes	sis,	
	Synthesizable	Subsets, Te	st of Impl	ementation	ons on FPGA		
	Evaluation Bo	ards					
Prerequisites	Recommended	:					
	MA-INF 4207	- Dynamic	ally Recor	ıfigurable	Systems		
Format	Teaching forma	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	ependent s	study		
Exam achievements	Oral presentat	ion, writter	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
Literature	Technical docu	imentation					

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)	· -					
- '	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 (not gra	<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	Duration	ı	Freque	ency		
270 h	9 CP	1 semes	ter	at leas	st every 2	years	
Module	PD. Dr. Volke	r Steinha	ge				
coordinator							
Lecturer(s)	PD. Dr. Volke	PD. Dr. Volker Steinhage					
Classification	Programme			Mode	Seme	ster	
Classification	M. Sc. Compu	iter Scienc	ce	Optiona	al 2. or	3.	
Technical skills	Competence to	o impleme	ent a	lgorith	ns for ser	nsor data	
	interpretation,	efficient l	hand	lling an	d testing	, documentation	١.
Soft skills	Efficient imple	ementation	n of	complex	k algorith	ms, abstract	
	thinking, docu	thinking, documentation of source code.					
Contents	Varying selecte	Varying selected up-to-date topics on sensor data interpretation					tion
Prerequisites	Required:						
	All of the follo	owing:					
	MA-INF 2201	– Compu	ter V	Vision			
	MA-INF 4206	- Selected	d To	pics in	Sensor D	ata Interpretation	on
To 4	Teaching forms	at	Grou	ıp size	h/week	Workload[h]	CP
Format	Lab			8	4	60 T / 210 S	9
	T = face-to-fa	ce teachin	ıg; S	= inde	pendent :	study	
Exam achievements	Oral presentat	ion, writt	en re	eport		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature	Relevant litera	ture will	be a	nnounc	ed at star	rt of the lab.	

Module	Lab Mobile	Robots				
MA-INF 4310	Las Wosie	100000				
Workload	Credit points	Duration	Frequer	ncy		
270 h	9 CP	1 semester	_	every y	ear	
Module	Prof. Dr. Sver	n Behnke	1			
coordinator						
Lecturer(s)	Prof. Dr. Sver	Behnke, Dr.	Nils Go	erke		
Classification	Programme		Mode	Semes		
Classification	M. Sc. Compu		Optional			
Technical skills	_	-	_	_	actical experience in	
		-		_	orithms for simple	
	structured rob	-	_			
	_	_		obots wi	ill be identified and	
Soft skills	implemented i			gool on	ionted grouls ability	
Soft skills	to analyze pro	`	_		iented work, ability	
			_		l teams, oral and	
	written presen	,	_			
	implementatio					
Contents	Robot middlev	vare (e.g. RO	S), robot	simulat	ion tools, basic	
	capabilities for	mobile robo	ts: reacti	ve contro	ol, SMPA	
	architecture, n	avigation, pa	th planni	ng, local	isation,	
				- \	M), visual based	
	object detection, learning robot control.					
Prerequisites	Recommended:					
	At least 1 of the following: BA-INF 132 – Grundlagen der Robotik					
	BA-INF 131 –	Intelligente S	Sehsysten	ne		
	MA-INF 1314	- Online Mo	tion Plan	$_{ m ning}$		
	MA-INF 2201	- Computer	Vision			
	MA-INF 4113	- Cognitive I	Robotics			
	MA-INF 4114					
	MA-INF 4203		_	System	S	
_	Teaching forms			h/week	Workload[h] CP	
Format	Lab		8	4	60 T / 210 S 9	
	T = face-to-fa	ce teaching: S	S = indep	endent s	study	
Exam achievements	Oral presentat				(graded)	
Study achievements		,			(not graded)	
Forms of media	Robots simula	tion environn	nents, rob	ot contr	ol middleware,	
	computer vision	on libraries, p	rogramm	ing, dem	onstration of robot	
	_ `		, . –	resentati	on and written	
	report of appr			D ' '	that D. Late	
	· · · · · · · · · · · · · · · · · · ·	_	d D. Fox:	Probab	ilistic Robotics.	
	MIT Press, 20		Movina	Intollian	neo Dublished by	
Litopature	• J. Buchii: M Advanced Rob		_	_	ence, Published by	
Literature	B. Siciliano,	•			~	
	Robotics, 2008		as., spi	111501 116	MIGDOOK UI	
	· · · · · · · · · · · · · · · · · · ·	,. tate-of-the-ar	t nublica	tions		

Module MA-INF 4312	Semantic D	ata Web '	Гесhnolo	gies		
Workload	Credit points	Duration	Freque	ncy		
180 h	6 CP	1 semeste:	every y	ear		
Module	Prof. Dr. Jens	Lehmann				
coordinator						
Lecturer(s)	Prof. Dr. Jens Dr. Maria Ma		Dr. Christ	oph Lang	ge,	
Classification	Programme M. Sc. Compu	ıter Science	Mode Optiona	Semest	ter	
Technical skills	The goal of th		_		re on the	
Toomised same	fundamentals, Web and infor	technologies mation retri	s and appleval. As p	ications of the	of the Semantic e lecture the bagies are explain	sic
Soft skills						
Contents	of data, inform standards and applications as projects (e.g. applications surfreebase). The practically oried discussed with • RDF syntax • RDF Scheme • ontologies in	ave been denation and keep technologie and have alreed in the lecture and data meand formation. Web and S. Web and S.	veloped for nowledge s are incre ady led to mantic wil a.org, Operation to the control of the re include: odel l semantic formal semantic demantic Weller	e machine on the Wasingly be a number of commence of a number of commence of the commence of t	readable exchanges. These eing used in r of exciting mercial or Google's by grounded an The topics (S) OWL s, query langual ations	d
Prerequisites	none				T	
_	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	ded)
Study achievements	Successful exe	rcise particij	oation		(not gra	$\overline{\operatorname{ded}}$
Forms of media						
Literature						

Module MA-INF 4313	Seminar Sen	mantic D	ata	Web	Technol	ogies	
Workload	Credit points	Duration		Frequer	ncv		
120 h	4 CP	1 semester at least every year					
Module	Prof. Dr. Jens	Lehmann					
coordinator							
Lecturer(s)	Dr. Christoph	Lange, Dr	. Ma	aria Ma	leshkova		
Classification	Programme		N	Mode	Semest	ter	
Classification	M. Sc. Compu	iter Science	e (Optional	$\lfloor 2.$		
Technical skills	Through the s	eminar, stu	ıden	ts will l	earn to w	ork with tools	and
	technologies of	f the Sema	ntic	Web as	well as a	ssess their	
	capabilities for	r given pro	blem	ns. They	will gair	n the ability to	
	understand ne	w research	resu	ılts pres	sented in	original scienti	fic
	papers.						
Soft skills	Ability to pres	sent and to	crit	ically d	iscuss tec	hnologies and	
	research result	s in the fra	amev	work of	Semantic	Web technolog	gies.
Contents	• technologies	such as tri	ple	stores, l	ink discov	very framework	ιs,
	NLP pipelines						
	• recent confe	rence and j	ourr	nal pape	ers		
Prerequisites	none						
Format	Teaching forms	at	Grou	ıp size	h/week	Workload[h]	CP
rormat	Seminar			10	2	30 T / 90 S	4
	T = face-to-fa	ce teaching	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	Oral presentation, written report (graded)					
Study achievements		(not graded)					
Forms of media							
Literature							

Module	Lab Semant	Lab Semantic Data Web Technologies				
MA-INF 4314						
Workload	Credit points Duration Frequency					
270 h	9 CP	1 semeste	er every	year		
Module	Prof. Dr. Jens	Lehmann	·			
coordinator						
Lecturer(s)	Prof. Dr. Jens	s Lehmann,	Dr. Mari	a Malesch	ıkova	
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Compu	iter Science	Option	al 2 .		
Technical skills	The students v	will carry o	ıt a pract	ical task	(project) in the	
	context of Sen	nantic Web	technolog	ies, includ	ling test and	
	documentation	n of the imp	lemented	software/	system.	
Soft skills	Ability to prop	perly preser	t and def	end design	n decisions, to	
	prepare readal	ole docume	ntation of	software;	skills in	
	constructively	collaborati	ng with o	thers in sr	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 presentation, written report (graded)					
Study achievements		(not graded)				
Forms of media						
Literature						

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						
CI :C ::	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:						
Trerequisites	Open-minded for new problem settings, Programming in different languages (C++, Python, Java), Critical approach to existing solutions, Research curiosity						
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	 [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	Game AI							
MA-INF 4319								
Workload	Credit points	Duration	Frequer	ıcy				
270 h	9 CP	1 semester	every ye	ear				
Module	Prof. Dr. Chris	tian Bauckha	ge					
coordinator								
Lecturer(s)	Prof. Dr. Christian Bauckhage							
` ,		Programme Mode Semester						
Classification	_	M. Sc. Computer Science Optional 2. or 3.						
Technical skills	Upon completio		_					
100mmodi simis	-				. 11:			
	• know about fu		-	artinciai in	telligence and n	.ow		
	they apply to co			1 6 1	. 11			
	• know about b			nods for pla	nning, problem			
	solving, and bel		_	. 1 . 6 . 1				
	• implement ba			thms for pla	anning, problem	L		
	solving, and bel		0					
	• implement nu							
Soft skills	Students will lea							
	artificial intellig							
	techniques for p			-				
	to implement th					ice		
	especially in the			mputer gan	ne agents.			
Contents	• historical over							
	• basic terms ar			-				
	• backward indi				_			
	• alpha-beta pr		restircted	searches, fe	atures, and			
	evaluation funct		_					
	• (traditional, u	,	ee search	algorithms				
	• Monte Carlo t				_			
	• algorithms for	-	_	-				
	• mathematical		computer a	algorithms i	for data clusteri	ng		
	• self organizing			/				
	• finite state ma							
	• fuzzy logic / f				g / programmıng	S		
	• probability th			vorks				
	Markov chains							
	• hidden Marko			_	*			
	Markov decisi							
	• the Bellman e			ent learning	r S			
	• temporal diffe	rence learning	5					
	• Q learning	, ,						
	• genetic algorit		etic progra	amming				
Prerequisites	Recommended			. 1.	1 1 1 1	•1• •		
	Students should					ollity		
	theory, and stat				ı	- CD		
.	Teaching forma	at G	roup size	 ' .	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	= indepen	dent study				
Exam achievements	Oral exam				(gra	aded)		
Study achievements	Successful exerc	ise participat	ion		(not gra	aded)		
Forms of media	• lecture slides	are made avai	lable onlii	ne				
	• lecture notes	with program	ming exan	nples are m	ade available on	line		
	Russell and Nor	vig, "Artificia	l Intellige	nce: A Mod	lern Approach"			
Literature	Millington. "Art	ificial Intellig	ence For (Games"				
		Millington, "Artificial Intelligence For Games"						
2100140410	MacKey "Inform	MacKay, "Information Theory, Inference, and Learning Algorithms"						

Module	Lab Representation Learning on Graphs					
MA-INF 4320						
Workload	Credit points Duration Frequency					
270 h	9 CP 1 semester every year					
Module	Prof. Dr. Emi	manuel Mü	ller			
coordinator						
Lecturer(s)	Prof. Dr. Emi	manuel Mü	ller			
Classification	Programme		Mode	Seme	ester	
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.	
Technical skills	The students	will carry o	ut a pract	ical task	(project) in the	
	context of repr	resentation	learning of	on graphs	, including test	and
	documentation	n of the im	plemented	software	/system.	
Soft skills	Ability to prop	perly prese	nt and def	end desig	n decisions, to	
	prepare readal	ble docume	ntation of	software;	skills in	
	constructively	collaborat	ng with o	thers in s	mall teams over	a
	longer period	of time; ab	lity to cla	ssify ones	own results into	o the
	state-of-the-ar	t of the res	p. area			
Contents						
Prerequisites	none					
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	study	
Exam achievements	Oral presentat	tion, writte	n report		(gra	ided)
Study achievements		(not graded)				
Forms of media						
Literature						

Module MA-INF 4321	Seminar Lea	Seminar Learning from Time Series					
Workload	Credit points	Credit points Duration Frequency					
120 h	4 CP	1 semester	every ye	ear			
Module coordinator	Prof. Dr. Emi	nanuel Mülle	er				
Lecturer(s)	Prof. Dr. Emr	nanuel Mülle	er				
G1 10 11	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	ter Science	Optional	2. or 3	3.		
Technical skills	Ability to und	erstand new	research r	esults pro	esented in origi	inal	
	scientific paper	rs.					
Soft skills	Ability to pres	sent and to c	ritically di	scuss the	ese results in th	ne	
	framework of	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	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentation, written report (graded)						
Study achievements		(not graded)					
Forms of media							
Literature							

Module MA-INF 4323	Pattern Recognition	on (2)						
Workload	Credit points Duratio	n Freque	ncv					
270 h	9 CP 1 semester every year							
Module	Prof. Dr. Christian Bauckhage							
coordinator								
Lecturer(s)	Prof. Dr. Christian Bauc	Prof. Dr. Christian Bauckhage						
	Programme	Mode	Semester					
Classification	M. Sc. Computer Science	Optional	2. or 3.					
Technical skills	Upon completion, student	ts should be a	ble to					
	• know about aspects of affect practical implement		nputing and	l how these may				
	of machine learning / pat	tern recogniti	on algorith	ms				
	• know about iterative al	gorithms for 1	nachine lea	rning / pattern				
	recognition with large dat			8 / 1				
	• implement numerically	robust algorit	hms for dat	ta dimensionalit	y			
	reduction							
	• implement numerically							
Soft skills	Students will learn about		_		ns of			
	robust implementations o							
	analysis and pattern reco	-						
	algorithms and dynamica							
Contents	implement them on theiradvanced concepts from			em mio practice.				
Contents	• QR-, spectral-, and sing	_		าร				
	• iterative algorithms for							
	• iterative algorithms for	-	-					
	• Hebbian learning and C	ja's rule for p	orincipal con	mpoentn analys	is			
	• auto-encoder networks							
	• associative memory net	works						
	Hopfield networks							
	• Hopfield networks for p	_						
	Hopfield networks for penergy minimization me		~	ag and pattorn				
	recognition	ethous in mac	iiiie ieariiii	ig and pattern				
	• latent factor models for	data analysis	3					
	• data matrix factorization							
	• multidimensional scalin	_						
	• manifold learning							
	• basic graph theory							
	• graph cuts and graph c							
	• graph diffusion processe							
	radial basis functions forradial basis functions for	-						
	• radial basis functions for							
Prerequisites	Recommended:	1 delibity Coll	111001011					
2 101044151105	Students should good wor	rking knowled	ge in linear	algebra, probal	oility			
	theory, and statistics. Ide	~	~		V			
	Pattern Recognition (1).							
	Teaching format	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 teaching	S = Independent	dent study					
Exam achievements	Schriftliche Prüfung				ided)			
Study achievements	Erfolgreiche Übungsteilna			(not gra	ided)			
Forms of media	• lecture slides are made							
	• lecture notes with progr							
	MacKay, "Information Th	neory, Inference	ce, and Lear	rning Algorithm	s"			
	Haykin, "Neural Network	s and Learnin	g Machines	TI .				
	Bishop, "Neural Networks	s for Pattern	Recognition	."				
Literature	Elden, "Matrix Methods i		_		"			
			_					
	Jameorn, Understanding	Skillicorn, "Understanding Complex Datasets"						

Module	Seminar Ad	Seminar Advanced Topics in Data Science					
MA-INF 4324							
Workload	Credit points	Duration	Frequency				
120 h	4 CP	1 semeste	nester every year				
Module	Prof. Dr. Eler	na Demidov	a				
coordinator							
Lecturer(s)	Prof. Dr. Eler	na Demidov	a				
Classification	Programme M. Sc. Compu	iter Science	Mode Optional	Semest 2. or 3			
Technical skills	This module of The students of	concentrates obtain skills t scientific l	on speciali in the inde iterature or	zed topic ependent, n specific	es in data scien , in-depth stud topics, discuss tific audience.	y of	
Soft skills	scientific conte	 Communication skills: oral and written presentation of scientific content. Self-competences: the ability to analyze problems, time management, creativity. 					
Contents	data generation	uding typica on, integrati n. Specialize	al steps of ton, cleaning data repr	he data s g, explora resentatio	science process: ation, modelling on and analytic	g	
Prerequisites	Recommended BA-INF 150 -		in die Dat	a Science)		
	Teaching forms		roup size	h/week	Workload[h]	СР	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching	S = indep	endent st	,	I	
Exam achievements	Oral presentat	tion, writter	report		(gra	ded)	
Study achievements	None				(not gra	$\overline{\mathrm{ded}}$	
Forms of media							
Literature	Relevant litera seminar	ature will be	e announced	l at the b	peginning of th	е	

Module	Lab Data S	Lab Data Science in Practice					
MA-INF 4325							
Workload	Credit points						
270 h	9 CP	1 semest		year			
Module	Prof. Dr. Eler	na Demido	<i>7</i> a				
coordinator							
Lecturer(s)	Prof. Dr. Eler	na Demido	<i>7</i> a				
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	e Option	al 2. or	3.		
Technical skills	This module c	oncentrate	s on pract	ical exper	ience in data		
	analytics. Par	ticipants a	cquire bas	ic knowled	lge and practica	1	
	experience in	the design	and imple	mentation	of data science		
	workflows for	_					
Soft skills	Communicate	tion skills:	the ability	to work	in teams.		
	Self-compete	ences: the a	ability to a	analyse pr	oblems and find		
	practical solut	ions. Time	managen	ent, creat	ivity, presentati	on	
	of results.						
Contents					ne learning-base		
	methods to so	lve data ar	alytics pro	oblems on	real-world data	sets	
	and evaluate p	proposed so	olutions.				
Prerequisites	Recommended	:					
	BA-INF 150 -	Einführun	g in die D	ata Scienc	e		
	MA-INF 4324	- Seminar	Advanced	Topics in	Data Science		
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	g; S = inde	ependent s	study		
Exam achievements	Oral presentat	ion, writte	n report		(gra	ded	
Study achievements	None	None (not graded)					
Forms of media							
Literature							

5 Master Thesis

MA-INF 0401	30 CP	Master Thesis	144
MA-INF 0402	2 CP	Master Seminar	145

Module MA-INF 0401	Master The	Master Thesis					
Workload	Credit points	Duration	Freque	ncv			
900 h	30 CP 1 semester every semester						
Module	0 0 0 0						
coordinator							
Lecturer(s)	All lecturers o	f computer	science				
Cl. 10 41	Programme		Mode	Se	emester		
Classification	M. Sc. Compu	iter Science	Compul	sory 4.			
Technical skills	Ability to solv	e a well-de	ined, signi	ficant res	earch problem		
	under supervis	sion, but in	principle i	ndepend	ently		
Soft skills					f considerable le		
			_	-	of form and styl	,	
	_	ecting solid	knowledge	about tl	ne state-of-the-a	rt in	
	the field						
Contents	_	_		_	of the areas of		
	computer scien	nce represe	nted in the	curricul	am		
Prerequisites	none			Ι.,			
	Teaching forms	at (Group size	h/week		CP	
	Independent			0	900 S	30	
Format	preparation of scientific thesis						
	individual coa	J		_	_		
	T = face-to-fa	ce teaching	S = inde	pendent :		>	
Exam achievements	Master Thesis (graded)						
Study achievements	(not graded)						
Forms of media							
Literature	Individual bib			-			
	relevant literature (depending on the topic of the thesis)						

Module MA-INF 0402	Master Sem	Master Seminar					
Workload	Credit points	Duration	Freque	ncv			
60 h	2 CP	1 semester	_	emester			
Module							
coordinator							
Lecturer(s)	All lecturers o	f computer s	cience				
CI :C .:	Programme		Mode	Se	mester		
Classification	M. Sc. Compu	ter Science	Compuls	sory 4.			
Technical skills	Ability to doc	ument and d	efend the	results o	f the thesis wor	k in	
	a scientifically	appropriate	style, tak	ing into o	consideration th	ne .	
	state-of-the-ar	t in research	in the res	sp. area			
Soft skills							
Contents	Topic, scientifi	c context, a	nd results	of the m	aster thesis		
Prerequisites	none						
Format	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar			2	30 T / 30 S	2	
	T = face-to-fa	ce teaching;	S = indep	endent s	tudy		
Exam achievements	Oral presentat	ion of final 1	esults		(gra	ded)	
Study achievements		(not graded)					
Forms of media							
T:4	Individual bib	liographic re	search rec	quired for	identifying		
Literature	relevant literat	ture (depend	ing on the	e topic of	the thesis)		