Module Handbook

for the

Master Programme "Computer Science"

at

Rheinischen Friedrich-Wilhelms-Universität Bonn

revised version: April 1, 2021

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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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	Frequency					
270 h	9 CP 1 semester at least every year							
Module	Prof. Dr. Jens	s Vygen						
coordinator								
Lecturer(s)	All lecturers of Discrete Mathematics							
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Option	al 1. or	2.			
Technical skills	Advanced knowledge of combinatorial optimization. Modelling					ng		
	and developme	ent of solution	n strateg	gies for co	mbinatorial			
	optimization p	optimization problems						
Soft skills		Mathematical modelling of practical problems, abstract						
		thinking, presentation of solutions to exercises						
Contents	Matchings, b-1	Matchings, b-matchings and T-joins, optimization over						
	matroids, sub	nodular fund	tion min	imization	, travelling			
	salesman prob	lem, polyhed	lral comb	inatorics,	NP-hard probl	ems		
Prerequisites	none							
	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP		
Format	Lecture			4	60 T / 105 S	5.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = inde	pendent s	study			
Exam achievements	Oral exam				(gra	ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	ded)		
Forms of media								
	• B. Korte, J.	Vygen: Con	binatoria	al Optimi	zation: Theory	and		
	Algorithms. Springer, 6th edition, 2018							
	• A. Schrijver:	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. Computer Science Optional 1. or							
Technical skills	-	Understanding of security concerns and measures, and of the						
		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. Compu		_		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	loomot	+ 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	Dr. Herman Haverkort						
Classification	Programme		Mode	Seme	ster			
	M. Sc. Compu		Optional	1-4.				
Technical skills	0				cepts in the are			
		-		_	and analysis of			
	_			-	of the complex	ity		
	of geometric c	_			owledge			
	autonomously							
Soft skills	Social compet	`			_			
	solutions, goal			,				
	competence (a	. ,	, -	, ,				
	· ·	commitment :	and 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	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						
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	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. Ann	Prof. Dr. Anne Driemel, Prof. Dr. Thomas Kesselheim,					
	Prof. Dr. Heik	o Röglin,	PD	Dr. Elm	ar Lange	tepe,	
	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	Freque	ncy				
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	$\overline{\mathbf{c}}$		
	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							
	• 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	- - · · · · · · · · · · · · · · · ·					
Module	Prof. Dr. Heil	Prof. Dr. Heiko Röglin					
coordinator		O					
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	e Semester			
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 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	ster at least every 2 years				
Module	Prof. Dr. Tho	mas Kesselh	eim				
coordinator							
Lecturer(s)	Prof. Dr. Thomas Kesselheim						
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Computer Science Optiona			al 2. or	3.		
Technical skills	Understanding	Inderstanding approaches for modeling uncertainty in					
	algorithmic th	algorithmic theory. Designing and analyzing algorithms with					
	performance g	performance guarantees in the context of uncertainty.					
Soft skills	Oral and 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 Al	Seminar Algorithmic Game Theory					
Workload	Credit points	Duration	Frequer	ncy			
120 h	4 CP	1 CP 1 semester every year					
Module	Prof. Dr. Thomas Kesselheim						
coordinator							
Lecturer(s)	Prof. Dr. Tho	mas Kessell	neim				
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	2. or 3.		
Technical skills	Ability to und	Ability to understand new research results presented in original					
	scientific pape	scientific papers.					
Soft skills	Ability to 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	r at least	every ye	ar		
Module	Prof. Dr. Peti	Prof. Dr. Petra Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Peti	a Mutzel					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	2. or 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	Prof. Dr. Petra Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Petr	Prof. Dr. Petra Mutzel					
Classification	Programme		Mode	Seme	ster		
Classification	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	erformanc	e Optin	nization	l		
MA-INF 1222			1_				
Workload	Credit points	Duration	Freque	-			
270 h	9 CP	P 1 semester every year					
Module	Prof. Dr. Petr	Prof. Dr. Petra Mutzel					
coordinator							
Lecturer(s)	Prof. Dr. Petr	Prof. Dr. Petra Mutzel, Dr. Sven Mallach					
Classification	Programme		Mode	Semes	ster		
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.		
Technical skills	Ability to desi	gn, analyze a	and imple	ement alg	orithms for		
	computational	computational analytics and optimization problems. The lab					
	also includes e	also includes experimental evaluation and documentation of the					
	implemented s	_					
Soft skills	Ability to prop	perly present	and defe	end design	decisions, to		
	prepare readal			_			
				,	nall teams over	a	
	longer period	of time; abili	ty to clas	sify ones	own results into	the	
	state-of-the-ar		-	v			
Contents							
Prerequisites	none						
D	Teaching forms	at Gro	up size	h/week	Workload[h]	CP	
Format	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media							
	The relevant li		1	1 .			

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 Programme	r. Maiek K	Mode	Seme	at on		
Classification	M. Sc. Compu	iter Science	Options	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 methods and techniques					
Contents	The most defin	ning charact	eristic of	the Inter	net is that it was		
	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.						
					ble and unifying techniques		
					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	ester 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 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	
rormat	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	Prof. Dr. Heiko Röglin, PD Dr. Elmar Langetepe,					
	Dr. Herman H	Dr. Herman Haverkort					
Classification	Programme		Mode	Semes	ter		
	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	lents 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	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. Rein		-	-				
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	9 CP 1 semester every year							
Module	apl. Prof. Dr.	Frank Ku	rth						
coordinator									
Lecturer(s)	apl. Prof. Dr.	Frank Ku	rth, Prof.	Dr. Micha	ael Clausen				
Classification	Programme		Mode	Seme	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 soft geometric and design hape retrieved by the soft stations have a soft soft soft soft soft soft soft soft	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 softwee similarity to not and shape space or the space or t	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 retriev oncepts of st cations ric and radio on 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 softwee similarity to not and shape space or the space or t	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 softwee similarity to not and shape space or the space or t	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 softwee similarity to not and shape space or the space or t	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 softwee similarity to not and shape space or the space or t	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 souncics 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 softwee similarity to not and shape space or the space or t	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 souncics 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 this 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 applications applications.	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	 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	ter Anima	ation					
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	reas 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			
		orepare 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	uisition and	l Analys	sis in N	euroscience			
MA-INF 2312								
Workload	Credit points	Duration	Frequer	ıcy				
180 h	6 CP	1 semester	at least	every 2	years			
Module	Prof. Dr. Tho	mas Schultz	-1					
coordinator								
Lecturer(s)	Prof. Dr. Tho	omas 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	Imaging 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	overs the full	image for	mation ar	nd analysis pip	eline		
	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	Functional MRI Data Analysis. Cambridge University Press,							
	2011		-	J	Ü			
	• D.K. Jones:	Diffusion M	RI: Theor	y, Method	d, and			
	Applications,		•					

Credit points Duration Frequency every year	Module	Deep Learn	ing for Vi	sual Rec	cognition	n		
Module Prof. Dr. Reinhard Klein Prof. Dr. Michael Weinmann	MA-INF 2313	O 114	D 41	ъ				
Prof. Dr. Reinhard Klein		=	1					
Classification Dr. Michael Weinmann								
Dr. Michael Weinmann		Prof. Dr. Rei	nhard Klein					
Programme Mode Semester		D 36:1 17						
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		
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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	
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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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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		networks and then progress to state-of-the-art convolutional and						
$ \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	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			
	processing implement s implement a implement a implement a	imple and ad lgorithms fo lgorithms fo lgorithms fo lgorithms fo	lvanced ar creating image versions image recolor ar	algorithms g artistic i varping norphing nd intensi	ty manipulation			
Soft skills	Students will I foundations of editing. They	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	photography mathematica coordinate s Fourier trans low- band-, a mean- and C median filter efficient imp interpolation artistic imag image warpi image morph	 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 						
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	rof. Dr. Matthias Hullin						
Classification	Programme	Programme Mode			Semester			
Classification	M. Sc. Compu	M. Sc. Computer Science Op		al 2. or	2. or 3.			
Technical skills								
Soft skills								
Contents								
Prerequisites	none	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	Lab Digital Material Appearance						
Workload	Credit points	Duration	Freque	ency				
270 h	9 CP	1 semeste	every	year				
Module	Prof. Dr. Mat	thias Hullin						
coordinator								
Lecturer(s)	Prof. Dr. Mat	rof. Dr. Matthias Hullin						
Classification	Programme			Seme	ster			
Classification	M. Sc. Compu	M. Sc. Computer Science O		al 2. or	2. or 3.			
Technical skills								
Soft skills								
Contents								
Prerequisites	none	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 310	6 L2E2	6 CP	Privacy in Ubiquitous Computing	70
MA-INF 320	1 L2E2	6 CP	Selected Topics in Network Security	71
MA-INF 320	2 L2E2	6 CP	Mobile Communication	72
MA-INF 320	7 L2E2	6 CP	Advanced Logic Programming	73
MA-INF 320	9 Sem2	4 CP	Seminar Selected Topics in Communication	
			Management	74
MA-INF 321	.5 Sem2	4 CP	Seminar Selected Topics in Malware Analysis and	
			Computer/Network Security	75
MA-INF 321	6 Sem2	4 CP	Seminar Sensor Data Fusion	76
MA-INF 321	8 Sem2	4 CP	Seminar Model-Driven Software Engineering	77
MA-INF 321	9 Lab4	9 CP	Lab Model-Driven Software Engineering	7 8
MA-INF 322	22 L4E2	9 CP	eSecurity	79
MA-INF 322	27 Sem2	4 CP	Seminar Anonymity and Privacy on the Internet	80
MA-INF 322	29 Lab4	9 CP	Lab IT-Security	81
MA-INF 323	33 L2E2	6 CP	Advanced Sensor Data Fusion in Distributed Systems	82
MA-INF 323	84 Lab4	9 CP	Lab Mobile Sensing Systems	83
MA-INF 323	S 5 L2E2	6 CP	Usable Security and Privacy	84
MA-INF 323	86 L2E2	6 CP	IT Security	
MA-INF 323	7 L2E2	6 CP	Array Signal and Multi-channel Processing	86
MA-INF 323	88 L2E2	6 CP	Side Channel Attacks	87
MA-INF 330	14 Lab4	9 CP	Lab Communication and Communicating Devices	88
MA-INF 330	05 Lab4	9 CP	Lab Information Systems	89
MA-INF 330	9 Lab4	9 CP	Lab Malware Analysis	90
MA-INF 331	0 L2E2	6 CP	Introduction to Sensor Data Fusion - Methods and	
			Applications	91
MA-INF 331				
			Lab Sensor Data Fusion	93
MA-INF 331	7 Sem2	4 CP	Seminar Selected Topics in IT Security	94
MA-INF 331	8 Sem2	4 CP	Seminar Verification of Complex Systems	95
MA-INF 331	9 Lab4	9 CP	Lab Usable Security and Privacy	96
MA-INF 332	20 Lab4	9 CP	Lab Security in Distributed Systems	97
MA-INF 332			Seminar Usable Security and Privacy	98
MA-INF 332	22 L2E2	6 CP	Program Analysis and Binary Exploitation	99
MA-INF 332			Lab Fuzzing Bootcamp	
MA-INF 332	Lab4	9 CP	Lab Design of Usable Security Mechanisms	101

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	Selected To	pics in N	Vet	work S	ecurity				
MA-INF 3201									
Workload	Credit points	Duration		Freque	ncy				
180 h	6 CP	1 semest	ter	every y	rear				
Module	Prof. Dr. Pete	Prof. Dr. Peter Martini							
coordinator									
Lecturer(s)	Prof. Dr. Pete	er Martini,	Dr	. Dr. ha	bil. Robe	rt Koch			
Classification	Programme			Mode	Semes	ter			
Classification	M. Sc. Compu	iter Scienc	e	Optiona	$1 \mid 2$. or 3	3.			
Technical skills	The students l	learn funda	ame	ntal con	cepts of n	etwork security	y.		
	This includes	risks and v	vuln	erabilitie	es of toda	y's computer			
	networks, cond	cepts to in	crea	se and t	estăthe le	evel of security	in		
	theseănetwork	s, a real-li	fe oı	riented i	ntroductio	on to encryptic	n		
	techniques, the	eir applica	tion	s and th	eir weakr	nesses and a			
	discussion of u	pcoming 1	new	technolo	ogies.				
Soft skills	Theoretical ex	ercises to	supp	port in-d	lepth und	erstanding of			
	lecture topics	and to stir	nula	ate discu	ssions, pr	actical exercise	es in		
	teamwork to s	teamwork to support time management, targeted organisation of practical work and critical discussion of own and others' results.							
	practical work								
Contents	Threats and a	Threats and attack scenarios, cyber kill chain, organizational							
	aspects, technical aspects: securing networks using differ								
	concepts like f	irewalls an	ıd II	DS (intri	usion dete	ection systems)	,		
	security protoc	security protocols for different protocol layers, penetration							
	testing, high s	ecurity ne	twor	ks, secu	rity aspec	ets of IPv6, pri	vacy		
	protection, end	cryption.							
Prerequisites	Recommended								
		_				ication system	S		
	(e.g. BA-INF					=			
	,	ıelor Progi	ramı	me Infor	matik, Er	nglish lecture s	lides		
	available)								
	Teaching forms	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-face teaching; S = independent study								
Exam achievements	Written exam					(gra	ded)		
Study achievements	Successful exe	rcise parti	cipa	tion		(not gra	ded)		
Forms of media									
	• William Stal	llings, Law	rie	Brown, (Computer	Security:			
	• William Stallings, Lawrie Brown, Computer Security: Principles and Practice (3rd Edition), Pearson								
T it anotes	• Christoph B	usch, Step	hen	D. Wolt	husen: N	etzwerksicherh	eit,		
Literature	Spektrum Aka	demischer	Vei	rlag					
	• Matt Bishop	: Introduc	ction	n to Con	nputer Sec	curity, Addison	l		
	Wesley								

Module	Mobile Con	nmunicat	ion									
MA-INF 3202			71011									
Workload	Credit points	Duration	Frequ	encv								
180 h	6 CP	1 semest	_	-								
Module	Prof. Dr. Pete			J								
coordinator												
Lecturer(s)	Prof. Dr. Pete	er Martini.	Dr. Mattl	nias 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	to current challenges										
Soft skills	Theoretical ex	ercises to s	support in-	depth und	erstanding of							
	_	ecture 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						
	before the beg	inning of t	he lecture			• 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						
Lecturer (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 of			
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	ıcy			
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., Esta 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 gamests	Frequency				
	0 0						
Module	Prof. Dr. Michael Meier						
coordinator	D (D) () 1) ()						
Lecturer(s)	Prof. Dr. Michael Meier						
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						
	risks and vulnerabilities of today's information technology as						
	well as concepts to increase the level of IT security, their						
	applications and their weaknesses.						
Soft skills	Theoretical exercises to support in-depth understanding of						
	lecture topics and to stimulate discussions, practical exercises in						
		teamwork to support time management, targeted organization of					
	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	Duration Frequency				
180 h	6 CP 1 semester every year						
Module	Prof. Dr. Wol	fgang Koch					
coordinator							
Lecturer(s)	Dr. Marc Oispuu						
Classification	Programme Mode Semester						
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.		
Technical skills	Localization of	Localization of multiple sources using passive sensors is a					
	fundamental t	fundamental task encountered in various fields like wireless					
	communication	n, radar, son	ar, and sei	smology.	In this lecture, a		
	unified framew	vork for elect	romagneti	c and acc	oustic signals and		
	signal processi	signal processing techniques are presented. Furthermore, the					
	sensor calibrat	sensor calibration, direction finding, and bearings-only					
	localization pr	oblem are co	nsidered.	Special a	pplications are		
	emphasized, li	emphasized, like small airborne arrays for unmanned aerial					
	vehicles (UAVs).						
Soft skills	Mathematical derivation of algorithms, applications of						
		mathematical results on estimation theory					
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 MA-INF 3238	Side Channel Attacks						
Workload	Credit points	Duration	Freque	ncy			
180 h	6 CP	1 semester	_	-			
Module	Prof. Dr. Michael Meier						
coordinator							
Lecturer(s)	Prof. Dr. Michael Meier, Dr. Felix Boes						
	Programme	,	Mode	Semest	ter		
Classification	M. Sc. Compu	iter Science	Optiona	$1 \mid 2$. or 3	3.		
Technical skills	• Students are		-		oractical side		
	channel effects			1			
	• Students lea	rn technique	s to utilize	e these eff	ects to circum	vent	
	security mecha	_					
	·		nels as w	ell as side	channel attac	ks	
	and microarch	and microarchitectural attacks on modern CPUs.					
Soft skills	Theoretical exercises to support in-depth understanding of						
	lecture topics and to stimulate discussions, practical exercises in						
	teamwork to support time management, targeted organization of						
	practical work and critical discussion of own and others' results.						
Contents	• Theoretical foundations of side channel effects and attacks as						
	well as						
	• covert chann	nels,					
	• differential p	ower analysi	s,				
	• padding orac	cle,					
	• RSA timing	attacks,					
	• cache based	side channel	effects,				
	• microarchite	ctural attack	s (Spectre	e)			
Prerequisites	Recommended	:					
	Fundamental l	knowledge al	out IT Se	ecurity, op	perating systen	ns	
	and						
	statistics is ad	vantageous l	out not ma	andatory.			
	Teaching forms		oup size	h/week	Workload[h]	CP	
Format	Lecture			2	30 T / 45 S	2.5	
	Exercises			2	30 T / 75 S	3.5	
	T = face-to-fa	ce teaching:	S = inder	endent st	'	1	
Exam achievements	Written Exam			,		ded)	
Study achievements			me		,-		
-	Erfolgreiche Übungsteilnahme (not graded)						
Forms of media							

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

Module MA-INF 3305	Lab Information Systems						
Workload	Condit mainta	Duration	The sure				
270 h	Credit points 9 CP	oints Duration Frequency 1 semester at least every year					
Module	Dr. Thomas Bode						
coordinator	Dr. Thomas bode						
	Dr. Thomas F	Rodo					
Lecturer(s)	Programme	Dr. Thomas Bode Programme Mode Semester					
Classification		tor Caionas	Mode				
m 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	M. Sc. Compu		_				
Technical skills		The students will carry out a practical task (project) in the					
		context of information systems, including test and					
	documentation of the implemented software/system.						
Soft skills		Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in					
		constructively collaborating with others in small teams over a					
				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						
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	ependent s	study		
Exam achievements	Oral presentat	tion, written	report		(gra	ided)	
Study achievements					(not gra	$\overline{\mathrm{ded}}$	
Forms of media							
Literature	The relevant liprevious seme		l be anno	ounced to	wards the end o	f the	

Credit points Duration Frequency every semester	Module	Lab Malware Analysis						
Prof. Dr. Peter Martini Prof. Dr. Michael Meier	MA-INF 3309							
Prof. Dr. Peter Martini	Workload	Credit points	Duration	Freque	Frequency			
Color Colo	270 h			every s	semester			
Prof. Dr. Peter Martini, Prof. Dr. Michael Meier	Module	Prof. Dr. Peter Martini						
Programme Mode Semester M. Sc. Computer Science Optional 3.	coordinator							
Classification M. Sc. Computer Science Optional 3. The students will carry out a practical 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. Work in small teams and cooperate with other teams in a group ability to make design decisions in a practical task; present and discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work carried out Contents Selected topics close to current research in the area of communication systems, malware analysis, computer and network security. Prerequisites Required: Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236) Format Group size h/week Workload[h] Clab Reaching format Group size h/week Workload[h] Clab Reaching format Group size h/week Group size size h/week Group size size h/week Group size size size size size size size size	Lecturer(s)	Prof. Dr. Pete	er Martini, P	rof. Dr. 1	Michael N	Meier		
The students will carry out a practical 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. Work in small teams and cooperate with other teams in a group ability to make design decisions in a practical task; present and discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work carried out Contents Selected topics close to current research in the area of communication systems, malware analysis, computer and network security. Prerequisites Required: Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236) Format Group size h/week Workload[h] C1 Lab Reaching format Group size h/week Workload[h] C1 Lab Reaching format	Classification	_						
ability to make design decisions in a practical task; present and discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work carried out Contents Selected topics close to current research in the area of communication systems, malware analysis, computer and network security. Prerequisites Required: Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236) Format Group size h/week Workload[h] CI Lab Required: Successful Completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236)	Technical skills	The students context of com Malware Anal	The students will carry out a practical task (project) in the context of communication systems with a specific topic focus on Malware Analysis and Computer/Network Security, including					
communication systems, malware analysis, computer and network security. Required: Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236) Teaching format Group size h/week Workload[h] Clab 8 4 60 T / 210 S 9	Soft skills	discuss (interim and final) results in the team/group and to other students; prepare written documentation of the work						
Successful completion of at least one of the following lectures: Principles of Distributed Systems (MA-INF3105), Network Security (MA-INF3201), Mobile Communication (MA-INF3202) IT Security (MA-INF3236) Teaching format Group size h/week Workload[h] Cl Lab 8 4 60 T / 210 S 9	Contents	communication	n systems, m					
Lab 8 4 60 T / 210 S 9	Prerequisites	Successful com Principles of I Security (MA- IT Security (M	Distributed S INF3201), M MA-INF3236	ystems (1 Iobile Co	MA-INF3 mmunicat	105), Network		
Lab 8 4 60 T / 210 S 9	Format	_	at Gr	oup size	h/week		CP	
T - face to face teaching: S - independent study	Format	Lab		8	4	60 T / 210 S	9	
$\Gamma = 1ace^{-10}$ -race reaching, $\rho = 1ace$ -race reaching		T = face-to-fa	ce teaching;	S = inder	pendent s	study		
	Exam achievements				-		ded)	
Study achievements (not graded	Study achievements	_	•			(not gra	$\overline{\operatorname{ded}}$	
, ,	Forms of media					, 5		
Literature	Literature							

Module MA-INF 3310	Introduction to Sensor Data Fusion - Methods and Applications						
Workload	Credit points Duration Frequency						
180 h	6 CP						
Module	P.D. Dr. Wolfgang Koch						
coordinator	T.D. DI. Wongang Hoon						
Lecturer(s)	P.D. Dr. Wolfgang Koch						
Lecturer (b)	Programme	84118 110011	Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona				
Technical skills	All participants shall get known to the basic theory of sensor data fusion. The lecture starts with preliminaries on how to handle uncertain data and knowledge within analytical calculus. Then, the fundamental and well-known Kalman filter is derived. Based on this tracking scheme, further approaches to a wide spectrum of applications will be shown. All algorithms will be motivated by examples from ongoing research projects, industrial cooperations, and impressions of current demonstration hardware.						
Soft skills	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. Mathematical derivation of algorithms, application of					cal	
	mathematical						
Contents	Gaussian prob Multi-Hypothe Retrodiction,	esis-Trackier	, Interacti	ng Multip	ole Model Filte	r,	
Prerequisites	none	Г			T		
	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Lecture Exercises			$\frac{2}{2}$	30 T / 45 S 30 T / 75 S	2.5 3.5	
	T = face-to-fa	ce teaching;	S = indep	endent st	cudy		
Exam achievements	Oral exam	<u> </u>				ded)	
Study achievements	Successful exe	rcise particij	oation		(not gra		
Forms of media					<u> </u>		
Literature	Framework an	W. Koch: "Tracking and Sensor Data Fusion: Methodological Framework and Selected Applications", Springer, 2014. Y. Bar-Shalom: "Estimation with Applications to Tracking and					
	Navigation", V				o o macking o	.IIU	

Module	Topics in Applied Cryptography						
MA-INF 3311							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semester	every	year			
Module	Prof. Dr. Joachim von zur Gathen						
coordinator							
Lecturer(s)	Prof. Dr. Joachim von zur Gathen, Dr. Michael Nüsken						
Classification	Programme		Mode	Semes	ster		
Classification	M. Sc. Compu	M. Sc. Computer Science Optional 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, a	One varying, advanced topic related to current research in					
	applied crypto	applied cryptography, 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. Wolfgang Koch						
coordinator	Tibi bir Wongang Hoon						
Lecturer(s)	P.D. Dr. Wolf	P.D. Dr. Wolfgang Koch					
	Programme	Programme Mode Semester					
Classification	M. Sc. Compu	iter Science	Opti	onal	3.		
Technical skills	The students	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 the context of a main goal.						
	Results will be	exchange	d and in	itegra	ted via	software interfa	aces.
Contents	Varying select	ed topics o	n senso	r data	a fusion		
Prerequisites	none						
Format	Teaching forms	at G	roup siz	ze h	/week	Workload[h]	CP
Format	Lab		8		4	60 T / 210 S	9
	T = face-to-fa	ce teaching	S = in	ndepe	ndent s	study	
Exam achievements	Oral presentat	ion, writte	n repor	t		(gra	ded)
Study achievements						(not gra	ided)
Forms of media							
Literature	The relevant literature will be announced at the beginning of the						
Literature	lab.						

Module MA-INF 3317	Seminar Selected Topics in IT Security						
Workload	Credit points Duration Frequency						
120 h	4 CP	1 semester	every ye	ear			
Module	Prof. Dr. Mich	nael Meier					
coordinator							
Lecturer(s)	Prof. Dr. Mich	Prof. Dr. Michael Meier, Prof. Dr. Peter Martini					
Classification	Programme	Programme Mode Semester					
Classification	M. Sc. Computer Science Optional 2.						
Technical skills	Ability to understand new research results presented in original						
	scientific papers.						
Soft skills	Ability to present and to critically discuss these results in the						
	framework of the corresponding area.						
Contents	Current confer	ence and jou	ırnal papeı	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 = independent	endent st	udy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements	(not graded)						
Forms of media							
Literature							

Module	Seminar Verifi	ication o	f Comple	ex Systems				
MA-INF 3318	C 1:4:-4- D		Th					
Workload 120 h	•	uration semester	Frequence					
Module		CP 1 semester at least every 2 years unProf. Dr. Janis Voigtländer						
coordinator	Validation Dividual Volgenman							
Lecturer(s)	JunProf. Dr. Janis Voigtländer							
	Programme	11115 1018010	Mode	Semester				
Classification	M. Sc. Computer	Science	Optional	2. or 3.				
Technical skills				ecifying and verifying				
			_	software. Competence to				
	mine for profound	d knowledg	ge about a	given subject, in particular				
	acquiring and stu	dying orig	inal literat	ure. Understanding				
	scientific publicat	ions, often	written to	ersely. Distilling this into				
	_			of relevant vs. irrelevant				
		_		to others, in writing and in				
	•	m with an audience.						
	Ability to discuss and evaluate presentations of fellow student and to constructively deal with critical feedback by others.							
C & 1:11				<u> </u>				
Soft skills		\	_	presenting talks, using				
	. = .	visual media, preparing a structured written document), social skills (motivating other students, ability to accept and formulate						
	, –							
	criticism), self competences (time management with long-ranging deadlines, self-study, ability to analyse, creative							
Contents	Techniques for analyzing the correctness of complex sys							
	such as software. Theoretical foundations for such techniques, as							
				s. Spectrum ranging from				
				sechniques within this				
	spectrum. Specifi	c themes of	of interest	include:				
	• Specification formalisms and languages							
	• Decision problems							
	Modelling desired properties of a system							
	• Model checking							
	• Theorem proving							
	• Static (flow) analysis, abstract interpretation							
	• Code analysis using heuristics							
	 Testing (approaches, frameworks, coverage criteria) Runtime verification (instrumentation, monitoring) 							
		`		,				
	• Applications and pragmatics of verification							
	A selection of top	oics will be	made in e	each semester.				
Prerequisites	none		, 1.					
Format	Teaching format	Gro		h/week Workload[h] CP				
	Seminar		10	2 30 T / 90 S 4				
	T = face-to-face							
Exam achievements	Oral presentation	, written r	report	(graded)				
Study achievements				(not graded)				
Forms of media	TD1 1 . 1	, ,11	1	1				
Literature	The relevant liter	ature will	be announ	ced in time.				

Module	Lab Usable Security and Privacy						
MA-INF 3319							
Workload	Credit points Duration Frequency						
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Mat	thew Smith					
coordinator							
Lecturer(s)	Prof. Dr. Mat	thew Smith					
Classification	Programme	Programme Mode Semester					
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 create and defend a scientific user study						
Contents	Students have a great degree of freedom to chose 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 graded)					
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	r every year			
Module	Prof. Dr. Mat	thew Smith					
coordinator							
Lecturer(s)	Prof. Dr. Matthew Smith						
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	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 s	implemented software/system.					
	Strong program	mming skill	s required	_			
Soft skills		Ability to properly present and defend design decisions, to					
	prepare readal			_	,		
				,	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	Credit points Duration Frequency					
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Matthew Smith						
coordinator							
Lecturer(s)	Prof. Dr. Mat	Prof. Dr. Matthew Smith					
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	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 pres	ent and to c	ritically di	scuss the	ese results in th	ie –	
	framework of t	he correspon	nding area	•			
Contents	Current confer	ence and jou	ırnal 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-fac	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 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. Computer Science Optional 2. or 3.							
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.					v to n as e neap		
Prerequisites	Required:							
	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 have basic knowledge of the Linux operating system							
	(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 teaching; S = independent study							
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	Lab Fuzzing Bootcamp					
MA-INF 3323							
Workload	Credit points	Duration	Fre	Frequency			
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Matthew Smith						
coordinator							
Lecturer(s)	Prof. Dr. Mat	thew Smit	h				
Classification	Programme		Mod	e	Semes	ster	
Classification	M. Sc. Compu	iter Scienc	e Opti	onal	2. or	3.	
Technical skills	The students	will carry	out a pra	actica	l task (project) in the	
	context of fuzz testing, including test and documentation of the						
	implemented s	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	Prof. Dr. Matthew Smith					
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	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 Learning	103
MA-INF 4112	L2E2	6 CP	Intelligent Learning and Analysis Systems: Data Mining	
		0 01	and Knowledge Discovery	
MA-INF 4113	L2E2	6 CP	Cognitive Robotics	
MA-INF 4114			Robot Learning	
MA-INF 4201			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	
MA-INF 4209			Seminar Principles of Data Mining and Learning	111
1111 1111 4200	DCIIIZ	101	Algorithms	119
MA-INF 4210	Sem2	4 CP	3	
MA-INF 4211				
MA-INF 4212				
MA-INF 4213			Seminar Humanoid Robots	
MA-INF 4214			Lab Humanoid Robots	
MA-INF 4215			Humanoid Robotics	
MA-INF 4216			Data Mining and Machine Learning Methods in	110
WIII II 11 4210	112112	0 01	Bioinformatics	119
MA-INF 4217	Sem2	4 CP		110
1411 11 1211	501112	1 01	Sciences	120
MA-INF 4218	Lab4	9 CP	Lab Modeling and Simulation	
			Lab Parallel Computing for Mobile Robotics	
			Foundations of Data Science	
			Pattern Recognition (1)	
			Advanced Methods of Information Retrieval	
MA-INF 4231				
MA-INF 4232			Lab Information Retrieval in Practice	
			Advanced Learning Systems	
			Learning from Non-Standard Data	
			Lab Cognitive Robotics	
			Lab Development and Application of Data Mining and	100
WIII II 1000	Labi	5 01	Learning Systems	131
MA-INF 4307	Lab4	9 CP	Lab Field Programmable Gate Arrays	
			Lab Vision Systems	
			Lab Sensor Data Interpretation	
			Lab Mobile Robots	
			Semantic Data Web Technologies	
MA-INF 4313			<u> </u>	
			Lab Semantic Data Web Technologies	
			Seminar Representation Learning for Big Data	100
1010	501112	1 01	Analytics	139
MA-INF 4319	L4E2	9 CP	Game AI	
			Lab Representation Learning on Graphs	
			Seminar Learning from Time Series	
			Pattern Recognition (2)	
			Seminar Advanced Topics in Data Science	
			Lab Data Science in Practice	

Module MA-INF 4111	Intelligent l Learning	Learning a	nd Ana	lysis Sys	stems: Mach	nine			
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP	1 semeste	r every y	vear					
Module	Prof. Dr. Stef	an Wrobel							
coordinator									
Lecturer(s)	Prof. Dr. Stef	an Wrobel	T						
Classification	Programme		Mode	Semest					
	M. Sc. Compu		Optiona						
Technical skills	This module is one of two complementary modules in which								
	_	students gain an understanding of the most important							
		paradigms and methods of intelligent learning systems as they are used in data analysis and/or for implementing adaptive							
		-	•	_	owledge discov	erv			
	`				=	-			
	· · · · · · · · · · · · · · · · · · ·	n databases). This module concentrates on the core task of predictive learning from examples and on agent learning, and							
	teaches the ma	teaches the main classes of algorithms for these tasks. At the							
	end of the mo			_	_				
	appropriate m		·	•	•				
		earning 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 4112 and can be taken before or after that module.							
Soft skills		Communicative skills (oral and written presentation of solutions,							
Soft Skills		,		_	(ability to acce				
	and formulate			_	•				
Contents	Types of learn	ing and ana	lysis tasks	, most im	portant				
	non-parametric and parametric methods for supervised learning								
	(e.g., decision			,	,				
	neighbourhood								
		einforcemen	t learning,	evaluatio	on and learning	S			
Prerequisites	theory. Required:								
Trerequisites	MA-INF 4102	- Intelligent	Learning	and Anal	vsis Systems h	as			
	not been passe	_	Learning	and mai		lab			
	Recommended								
	Prior knowled		oility theor	v. linear a	algebra, artifici	al			
	intelligence, in		-						
	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 = inder	oendent st	tudy				
Exam achievements	Written exam	3,				ded)			
Study achievements	Successful exe	rcise partici	oation		(not gra	ded)			
Forms of media	Lectures, exerc	cises, softwa	re package	es					
	- Tom Mitchel	l, Machine l	Learning, I	McGraw-I	Hill, 1997				
Literature	- Ian Witten,	Eibe Frank,	Data Min	ing, Morg	an Kauffmann	,			
	2000								

Module MA-INF 4112	Intelligent I Mining and				stems: Data			
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semester	every y	rear				
Module	Prof. Dr. Stef	an Wrobel	·					
coordinator								
Lecturer(s)	Prof. Dr. Wro	Prof. Dr. Wrobel						
Classification	Programme							
	M. Sc. Compu		Optiona					
Technical skills	This module is		-	·				
	students gain a		_		_			
		paradigms and methods of intelligent learning systems as they are used in data analysis and/or for implementing adaptive behaviour (machine learning, data mining, knowledge discovery in databases). This module concentrates on the core tasks of pattern discovery in databases and teaches the main classes of						
	,							
	· · · · · · · · · · · · · · · · · · ·							
	algorithms for	-						
	module, studer	,				UIIC		
	methods and s		_	_				
	applications ar			-		ıd		
	will know whe							
		development of algorithms and systems is necessary. This						
	module comple	_	=		=	or		
	after that module.							
Soft skills	Communicativ	e skills (ora	and writt	en presen	ntation of solut	ions,		
	discussions in	small teams), self com	petences	(ability to acce	$_{ m ept}$		
	and formulate	criticism, al	oility to ar	nalyze pro	blems)			
Contents		_	•	sis tasks, scalability techniques,				
	descriptive data mining methods, association rules, subgroups,							
	clustering, pre- and postprocessing, data storage (data							
	warehouses, O	, , =				xt,		
	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				,-	$\frac{\mathrm{ded}}{\mathrm{ded}}$		
Study achievements	Successful exer				(not gra	ded)		
Forms of media	Lectures, exerc	· · · · · · · · · · · · · · · · · · ·			IZ Œ			
	- Ian Witten,	Eibe Frank,	Data Mini	ıng, Morg	gan Kauffmann	,		
Literature	2000							
 -	- Jiawei Han, I			_	g: Concepts an	d		
	Techniques, Morgan Kaufmann, 2000							

Module MA-INF 4113	Cognitive F	Robotics						
	C	D4:	Th					
Workload	Credit points 6 CP	Duration 1 gamagter	Freque	=				
180 h	6 CP 1 semester every year Prof. Dr. Sven Behnke							
Module	Prof. Dr. Svei	n Bennke						
coordinator								
Lecturer(s)	Prof. Dr. Svei	n Behnke	l					
Classification	Programme	, G:	Mode	Semest				
	M. Sc. Compu		Optiona	I				
Technical skills		This lecture is one of two introductory lectures of the intelligency systems track. The lecture covers cognitive capabilities of						
				_	-			
	· · · · · · · · · · · · · · · · · · ·			J, .	perception, and	d		
action-planning in complex environments.								
	This module complements MA-INF 4114 and can be taken							
	before or after	pefore 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							
	and formulate	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-fa	ce teaching;	S = indep	endent st	udy	1		
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,		
	• R. Szeliski: Computer Vision: Algorithms and Applications, Springer 2010.							

Module	Robot Learning							
MA-INF 4114	G 11.	ъ						
Workload	Credit points	Duration	Frequency					
180 h	6 CP 1 semester every year Prof. Dr. Sven Behnke							
Module	Prof. Dr. Sver	n Behnke						
coordinator								
Lecturer(s)	Prof. Dr. Sver	n Behnke, Di						
Classification	Programme	~ .	Mode	Semest				
	M. Sc. Compu		Optiona					
Technical skills				-	es of the intellig	_		
		systems track. Creating autonomous robots that can learn to						
	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 = inder	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		ic						
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semester	every y	-				
Module	Prof. Dr. Sven Behnke							
coordinator								
Lecturer(s)	Prof. Dr. Sven Behnke, Dr. Nils Goerke							
	Programme	,	Mode	Semest	ter			
Classification	M. Sc. Compu	ter Science	Optional	l 1-3.				
Technical skills	Detailed under	Detailed understanding of the most important approaches and						
	principles of an	rtificial life. F	Knowledg	e and und	derstanding of	the		
	current state o	current state of research in the field of artificial life						
Soft skills	Capability to i	Capability to identify the state of the art in artificial life, and to						
	present and de	fend the four	d solutio	ns within	the exercises i	in		
	front of a grou	p of students	. Critical	discussion	on of the result	s of		
	the homework.							
Contents		Foundations of artificial life, cellular automata, Conway's "Game						
	,	of Life"; mechanisms for structural development; foundations of						
	nonlinear dyna				<i>'</i>			
	evolutionary m	_		_ ,				
		learning, artificial immune systems, adaptive behaviour,						
	self-organising		_	-	, and swarm			
	intelligence, pa	rticle swarm	optimiza	tion.				
Prerequisites	none							
_	Teaching forma	at Gro	oup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-face	ce teaching; S	S = indep	endent st	-			
Exam achievements	Written exam				(gra	ded)		
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 Ad				<i>'</i>			
	Electronic Library of Science, TELOS, Springer-Verlag							
	• Eric Bonabeau, Marco Dorigo, Guy Theraulaz: Swarm							
	Intelligence: Fr			-		c		
Literature	University Pre	ss, Santa Fe l	Institute	Studies ir	n the Science o	t t		
	Complexity.	oalso. El- (070 0 W A 1	i↓1	for C:1 1			
	Andrzej Osy Multipritoria E		-	_	_			
	Multicriteria I				-			
	Soft Computin	ig, rhysica-ve	eriag, A	opringer-	veriag Compar	ıy,		
	Heidelberg							

Module MA-INF 4203	Autonomou	s Mobile S	Systems					
Workload	Credit points	Duration	Freque	ісу				
180 h	6 CP	CP 1 semester every year						
Module	Prof. Dr. Sver	n Behnke	•					
coordinator								
Lecturer(s)	Dr. Dirk Schu	Dr. Dirk Schulz, Prof. Dr. Sven Behnke						
Classification	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	iter Science	Optional	l 2.				
Technical skills	Profound know	vledge of dev	elopment	and test	regarding struc	cture		
	and function of	and function of learning, autonomous, mobile systems;						
	Knowledge of	Knowledge of the computational, mathematical, and technical						
	requirements f	or the design	of auton	omous sys	stems for speci	fic		
	applications as	oplications and for specific functional environments						
Soft skills	The students	The students will be capable to assess applications for						
	autonomous m	atonomous mobile systems. They will be capable to identify						
	what part of t	hat part of the applications might be improved by using state						
	of the art deve	of the art developments. The student will learn how to plan and						
	implement a s	mplement a software project in small working groups.						
Contents	Requirements	for the imple	ementation	n of autor	nomous mobile			
	systems, e.g. f	or: map mal	king, dead	reckoning	g, localisation,			
	SLAM-method	ls, various p	rinciples o	f robot pa	ath planning;			
	methods for action planning. Comparison of different learning							
	paradigms for	specific app	ications.					
Prerequisites	Recommended	:						
	all of the follo	wing:						
	MA-INF 4101	- Theory of	Sensorime	otor Syste	ems			
	MA-INF 4113	- Cognitive	Robotics					
	Teaching forms	at G	roup size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching;	S = indep	endent st	udy			
Exam achievements	Oral exam	07	1			ded)		
Study achievements	Successful exe	rcise particip	ation		(not gra	$\overline{\operatorname{ded}}$		
Forms of media					<u> </u>			
	• J. Buchli: M	lobile Robots	s: Moving	Intelliger	nce, Published	by		
	Advanced Rob	otic Systems	s and Pro	Literatur	Verlag			
T:tanatums	Advanced Robotic Systems and Pro Literatur Verlag • Sebastian Thrun, Wolfram Burgard, Dieter Fox: Probabilistic							
Literature	Robotics, MIT	Press, 2005						
	Howie Chose	et et al.: Pri	nciples of	Robot Mo	otion, MIT-Pre	ess,		
	2005							

Module	Technical N	leural Net	5						
MA-INF 4204									
Workload	Credit points	Duration	Freque	-					
180 h	6 CP	1 semester	0.0	ear					
Module	Prof. Dr. Joac	chim K. Anla	uf						
coordinator									
Lecturer(s)	Prof. Dr. Joac	chim K. Anla		ils Goerk	e				
Classification	Programme		Mode	Semest	ter				
	M. Sc. Compu		Optiona	I					
Technical skills			dge of the most important neural network						
		_	_		elds of applicat				
		Knowledge and understanding of technical neural networks as							
		_			nilar to concep	ts of			
	brain function								
Soft skills					al paradigms f				
		eural networks that are capable to solve a given task. They can							
	_	iscuss the pro and cons with respect to efficiency and risk. The							
	_	vill 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 M. Bishop: Neural Networks for Pattern								
	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	Dynamically Reconfigurable Systems							
MA-INF 4207								
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semest	er at leas	t every 2	years			
Module	Prof. Dr. Joac	Prof. Dr. Joachim K. Anlauf						
coordinator								
Lecturer(s)	Prof. Dr. Joac	Prof. Dr. Joachim K. Anlauf						
Cl:64:	Programme		Mode	Semes	ter			
Classification	M. Sc. Compu	iter Scienc	e Optiona	d 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	ial skills (a	ability to so	lve proble	ms in small tea	ams,		
	discussions of	solution co	oncepts) sel	f competer	nces (ability to)		
	accept and for	mulate cri	ticism, abili	ity to anal	lyze problems)			
Contents	Architecture o	f FPGAs,	Configurab	le Logic B	Blocks, Wiring			
	Ressources, Sp	pecial Bloc	ks, Hardwa	re Descrip	tion Language	s,		
	Synthesis, Tec				oute, FPGA			
	Computing, Pa	artial Reco	onfigurabilit	y				
Prerequisites	none							
	Teaching forma	at	Group size	h/week	Workload[h]	CP		
Format	Lecture			2	30 T / 45 S	2.5		
	Exercises			2	30 T / 75 S	3.5		
	T = face-to-fa	ce teaching	g; S = inde	pendent st	tudy			
Exam achievements	Oral exam				(gra	ded)		
Study achievements	Successful exe	rcise partic	cipation		(not gra	ded)		
Forms of media								
Literature	Current resear	ch papers	and technic	cal docum	entation			

Module	Seminar Vi	sion Syste	ms					
MA-INF 4208	G 114 1 4	D						
Workload	Credit points 4 CP	Duration 1 semester	Frequency					
120 h	Prof. Dr. Svei		er every semester					
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			-				
		original scientific papers and to present them in a research talk						
	as well as in a							
Soft skills	_	elf-competences (time management, literature search,						
					and clear dida			
	_		,		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 Learn	ning						
	MA-INF 4204	- Technical	Neural Ne	ts				
Format	Teaching forms	at G	oup size	h/week	Workload[h]	CP		
rormat	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa			endent st				
Exam achievements	Oral presentat	ion, written	report		· -	ided)		
Study achievements					(not gra	ided)		
Forms of media	200	~						
	• R. Szeliski: Computer Vision: Algorithms and Applications,							
	Springer 2010.							
Literature	• C. M. Bishop: Pattern Recognition and Machine Learning,							
	Springer 2006.		~	,				
				uter Visi	ion: A Modern			
	Approach, Pre	entice Hall, 2	UU3.					

Module MA-INF 4209	Seminar Pr Algorithms	inciples o	f Data M	lining a	nd Learning		
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	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona				
Technical skills	•		-		zed topics in th	ie	
	area of machin	-	0	•	*		
		competence to independently study scientific literature, present					
	it to others an	-			, =		
	auditorium. L	auditorium. Learn how to scientifically present prior work by					
	others, in writ	others, in writing and in presentations.					
Soft skills	Communicative skills (preparing and presenting talks, written						
	presentation o	f contents i	n a longer	document), self compete	nces	
	(time manager	ment with l	ong-rangin	g deadline	es, ability to ac	cept	
	and formulate criticism, 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	Seminar Advanced Topics in Technical Informatics						cs
MA-INF 4210							
Workload	Credit points	Duration	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				
120 h	4 CP 1 semester at least every 2 years						
Module	Prof. Dr. Joachim K. Anlauf						
coordinator							
Lecturer(s)	Prof. Dr. Joac	chim K. A	nlau	ıf			
Classification	Programme			Mode	Semest	Semester	
Classification	M. Sc. Compu	iter Scienc	e	Optiona	l 2. or 3	3.	
Technical skills	Current Topic	Current Topics in Technical Informatics					
Soft skills	Communicativ	Communicative skills (preparing and presenting talks, preparing					
	a structured w	a structured written document), social skills (ability to accept					
	and formulate	criticism,	disc	cussions	of current	content) self	
	competences (time mana	agen	nent wit	h long-ran	nging deadlines	١,
	understanding	of research	h to	pics froi	n original	literature)	
Contents	Current topics	such as:	new	architec	tures of c	computers or	
	FPGAs (field)	programm	able	gate ar	rays) or n	ew application	s of
	dynamically re	econfigural	ble s	systems	- /		
Prerequisites	none						
D .	Teaching forma	at	Gro	oup size	h/week	Workload[h]	CP
Format	Seminar			10	2	30 T / 90 S	4
	T = face-to-fa	ce teachin	g; S	= indep	endent st	udy	
Exam achievements	Oral presentat	ion, writte	en r	eport		(gra	ded)
Study achievements						(not gra	ded)
Forms of media							
Literature	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	ter		
Classification	M. Sc. Compu	ter Science	Optional	tional 2. or 3.			
Technical skills	Knowledge in	advanced to	pics in the	area of o	cognitive robot:	ics,	
	such as robot	perception, a	action plan	ning, and	d robot learnin	g.	
	Ability to und	erstand new	research i	esults pro	esented in origi	inal	
	_	scientific papers and to present them in a research talk as well as					
	in a seminar re	_					
Soft skills		Self-competences (time management, literature search,					
	_	elf-study), communication skills (preparation and clear didactic					
	presentation of		·-	_			
	writing of sem		*		*		
	accept criticism						
Contents	_	Current 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.						
, ,							
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 Big	Data				
MA-INF 4212	a 11.						
Workload		Duration	Frequen				
180 h	6 CP	1 semester	every ye	ar			
Module	Prof. Dr. Stefan	Wrobel					
coordinator	D	41 DD D	A.f. 1 1 A	r 1			
Lecturer(s)	Dr. Tamas Horv	· · · · · · · · · · · · · · · · · · ·					
Classification	Programme M. Sc. Compute		Mode Optional	Semester 3. or 4.			
Technical skills	Participants acqu		_		nt aspects of big	,	
	data analytics ar	-	_				
	and big data dat		_	-			
	structured and u		_		-		
	computer because				~		
	with such a high			,			
Soft skills	Communicative						
	discussions in tea	ams), self-cor	npetences	(ability to	accept and form	ulate	
	criticism, ability					end"	
	task), social skill						
Contents	The module is of		ear, each	time concer	ntrating on one	or	
	more specific issu	ies, such as					
	- architectures as	nd procols fo	r big data	systems,			
	- distributed bat	ch and strea	m processi	ng systems	,		
	- non-standard d			0 0			
	- databases for s		_				
	- similarity searc		,				
	- synopses for ma						
	- classical data n		for massive	e data and	or data streams	5,	
	- mining massive	_		,		,	
	- applications.	0 1 /					
Prerequisites	Recommended:						
•	All of the followi	ng:					
	MA-INF 4111 –	_	earning an	d Analysis	Systems: Mach	ine	
	Learning	meemgene E		a many sis	Systems. Mach	1110	
	MA-INF 4112 –	Intelligent I	oorning on	d Analysis	Systems: Data		
	Mining and Kno	_	_	u Anaiysis	Systems. Data		
	Teaching forma		roup size	h/week	Workload[h]	CP	
Format	Lecture	G .	oup size	2	30 T / 45 S	2.5	
Tormat	Exercises			2	30 T / 75 S	3.5	
	T = face-to-face	teaching: S	– indepen	1	0017.00	0.0	
Exam achievements	Written exam	teaching, 5	– mdepen	dent study	(gra	aded)	
Study achievements	Successful exerci	se participat	ion		(not gra		
Forms of media	lectures, exercise				(810		
	- N. Marz and J.			inciples an	d best practices	of	
			-	-	-	-	
	scalable realtime data systems. Manning Pubn, 2014. - T. White: Hadoop The Definitive Guide. O'REILLY, 2012.						
		-					
Literature	- A. Rajaraman			ing of Mass	sive Datasets.		
	Cambridge Unive						
	- G. Cormode, N					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	1 semeste	r every se	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. Computer 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	self-written summary.					
Soft skills	Self-competen	Self-competences (time management, literature search,					
	self-study), co	self-study), communication skills (preparation of the talk, clear					
	didactic preser	ntation of te	chniques a	nd experi	imental results	١,	
	scientific discu	ssion, struc	ured writing	ng of sum	nmary), social	skills	
	(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 Robot	S					
Workload	Credit points	Duration	Freque	ncy				
270 h	9 CP	1 semester	every semester					
Module	Prof. Dr. Mar	en Bennewit	Z					
coordinator								
Lecturer(s)	Prof. Dr. Mar	en Bennewit	Z					
Classification	Programme		\mathbf{Mode}	Semes	ster			
Classification	M. Sc. Computer Science Optional 2.							
Technical skills	Practical expe	rience and in	-depth k	nowledge	in the design a	and		
	implementatio	n of percepti	on, state	estimation	on, environmen	ıt		
	representation	, navigation,	and mot	ion plann	ing techniques	for		
	humanoid robo	ots. In small	groups, t	the partic	cipants analyze	a		
	problem, realiz	ze a solution,	and peri	form an e	experimental			
	evaluation.							
Soft skills	_	Self-competences (time management, goal-oriented work, ability to analyze problems theoretically and to find practical						
	, ,				on in small tear	,		
			on of solu	itions, cr	itical examinat	ion		
	of implementa							
Contents	Robot middley		_			_		
		_	s, naviga	tion, and	l motion planni	ing		
	for humanoid							
Prerequisites	Recommended							
	At least 1 of the	9						
	MA-INF 4215	– Humanoid	Robotics	3				
	MA-INF 4113	- Cognitive	Robotics					
Format	Teaching forma	at Gro	up size	h/week	Workload[h]	CP		
Tormat	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching;	S = inder	pendent s	study			
Exam achievements	Oral presentat					aded)		
Study achievements					(not gra	aded)		
Forms of media								
	- S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press							
Literature	- B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics							
Diferature	- K. Harada, E Humanoid Rol	*	,	Eds.), M	otion Planning	for		
	- Selected pape	ers.						

Module	Humanoid	Robotics					
MA-INF 4215							
Workload	Credit points	Duration	Freque	Frequency			
180 h	6 CP	1 semester	at least	at least every 2 years			
Module	Prof. Dr. Mar	Prof. Dr. Maren Bennewitz					
coordinator							
Lecturer(s)	Prof. Dr. Mar	en Bennewit	Z				
Classification	Programme		Mode	Semes	ter		
Classification	M. Sc. Compu	iter Science	Optiona	l 2-4.			
Technical skills	This lecture co	overs techniq	ues for hu	ımanoid r	obots such as		
	perception, na	vigation, and	l motion p	planning.			
Soft skills	Communicativ	Communicative skills (oral and written presentation of solutions,					
	discussions in	small teams)	, ability t	o analyze	problems.		
Contents	Self-calibration	Self-calibration with least squares, 3D environment					
	representation	epresentations, self-localization with particle filters, footstep					
	planning, inve	rse kinemati	cs, whole-	body mot	ion planning w	γ ith	
	rapidly explor	rapidly exploring random trees, statistical testing.					
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	cudy		
Exam achievements	Oral exam				(gra	ded)	
Study achievements	Successful exe	rcise particip	ation		(not gra	$\overline{\operatorname{ded}}$	
Forms of media					· -	,	
	• S. Thrun, W	7. Burgard a	nd D. Fox	: Probabi	listic Robotics	•	
	MIT Press, 2005.						
T */	• B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics						
Literature					otion Planning		
	Humanoid Ro	bots, Springe	er	•			
	• Selected rese	earch papers.					

Module MA-INF 4216	Data Mining Bioinformat		chine Le	earning]	Methods in			
Workload	Credit points	Duration	Freque	ncy				
180 h	6 CP	1 semeste	r every y	rear				
Module	Dr. Holger Frö	bhlich						
coordinator	D III D"	11.1						
Lecturer(s)	Dr. Holger Frö Programme	hlich	Mode	Semest	t o.m.			
Classification	M. Sc. Compu	ter Science	Optiona	1	ter			
Technical skills	- understandin		-		al data mining	and		
	machine learni	_	_		Q			
	- understandin	g of their a	oplication	in bioinfo	ormatics			
Soft skills	- communication					to		
	exercises							
	- self-competer	nces: ability	to analyze	e applicat	ion problems a	nd		
	to formulate pe							
	- practical skill	ls: ability to	practical	ly implem	ent solutions			
	- social skills:	working in a	a small tea	ım with o	ther students			
Contents	This lecture gi	This lecture gives a broad overview about frequently used						
	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 topic					on in		
	bioinformatics:		a m the co	ontext of	тиен аррисат)11 111		
	- Short introdu		oinformati	cs and Bi	omedicine			
	- Statistical Ba							
	inference, stati				·	ic		
	regression, Prin				, g			
	- Clustering							
	- Hidden Mark	ov Models						
	- Principles of	Supervised	Machine I	Learning				
	- Elastic Net							
	- Basics of deep learning							
Prerequisites	none	r						
•	Teaching forma	ıt 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	ce teaching;	S = indep	endent st	tudy			
Exam achievements	Written exam		·			ded)		
Study achievements	Successful exer	cise partici	pation		(not gra	ded)		
Forms of media	T II4: D 7	D:11.:	I IN.: 1	(T) TO	C			
	T. Hastie, R. 7	,		n, The El	ements of			
T	Statistical Learning, Springer, 2008							
Literature	S.Boslaugh, P.				-	บช		
	N. Jones, P. Pe Algorithms, M			on to Bioi	informatics			

Module	Seminar Mad	chine Lea	rning M	ethods	in the Life	
MA-INF 4217	Sciences					
Workload	Credit points	Duration	Frequer	ncy		
120 h		1 semester	_	-		
Module	Dr. Holger Fröh	nlich				
coordinator						
Lecturer(s)	Dr. Holger Fröh	nlich				
Classification	Programme		Mode	Semes	ter	
	M. Sc. Comput		Optional			
Technical skills	- understanding					
	and their applic					
Soft skills	- communication	n: oral scie	ntific pres	entation of	of a defined top	oic
	- self-competences: ability to identify relevant literature for a given topic; ability to read, understand and analyze scientific publications					
	- social skills: ability to discuss a scientific topic with other students and the staff					
Contents	Machine learning techniques play a crucial role in modern life sciences, including biomedicine. The goal of this seminar is to discuss a variety of machine learning techniques in the context of their application to solve real-world problems in biomedicine.					to xt of
	Topics will be se	elected from	n the follo	wing area	as:	
	- Ensemble lear:	ning				
	- Survival and d	_	ression m	odels		
			ression in	odels		
	- Bayesian Netw			_		
	- Stochastic pro Mixture Models		Gaussian	Proceses	, Dirichlet Pro	cess
	- MCMC metho	ods				
	- Deep learning Networks	methods, e	.g. DNNs	, CNNs, 1	Deep Belief	
	- feature selection	on and non-	-linear em	bedding i	methods	
	- multi-modal d					
			•		l 4 4 l : 4 :	_ :
	Attendees will by a self-responsible		periorin r	esearcn a	bout their topi	.C 111
Prerequisites	Recommended: MA-INF 4216 – Bioinformatics	- Data Mini	ng and M	achine Le	earning Method	ls in
	Teaching format	Gı	oup size	h/week	Workload[h]	CP
Format	Seminar		10	2	30 T / 90 S	4
	T = face-to-face	teaching:	I	_	' '	_
Exam achievements	Oral presentation			onuciii st		ded)
Study achievements	orar presentation	, wiiouti	10P010		(not gra	
Forms of media	powerpoint				(220 810)
Literature	selected journal	and confer	ence pape	ers		
	- J		I · I ·			

Module	Lab Modeli	ng and Si	mulatior	1		
MA-INF 4218		J				
Workload	Credit points	Duration	Freque	ncy		
270 h	9 CP	1 semeste	e 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	ter Science	Optiona	$1 \mid 2.$		
Technical skills	- ability to des	- ability to describe a system via a model				
	- ability to cor its results	- ability to conduct a simulation study, visualize and interpret its results				
		- ability to implement self-written program modules in MATLAB, R or via usage of some other software				
Soft skills	- ability to communicate effectively in order to implement learned methods together with a team of other students					
	- ability to predecisions	esent and ex	plain resu	lts and to	o defend design	
Contents	Simulation and example, in sy		-		that arise, for ing approaches	are:
	- Boolean Netv	works				
	- ODEs					
Prerequisites	Recommended		Machine L	earning I	Methods in the	Life
Format	Teaching forma	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 = indep	endent s	study	
Exam achievements	Oral presentat	ion, written	report		(gra	ded)
Study achievements					(not gra	
Forms of media	powerpoint				·	<u> </u>
	- U. Alon, An	Introduction	n to System	ms Biolog	gy, CRC Press,	2007
Literature	- E.S. Allman Cambr.Univ.P		des "Math	ıematical	Models in Biol	ogy"

Module	Lab Parallel Computing for Mobile Robotics						
MA-INF 4226							
Workload	Credit points	Duration	Freque	Frequency			
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Maren Bennewitz						
coordinator							
Lecturer(s)	Prof. Dr. Mar	Prof. Dr. Maren Bennewitz					
Classification	Programme		Mode	Seme	Semester		
Classification	M. Sc. Compu	iter Science	Optiona	al 2.			
Technical skills	Students will make practical experience with the design and						
	implementation of parallelized algorithms in the context of						
	motion planni	motion planning and navigation.					
Soft skills	Ability to prop	perly presen	and defe	end design	n decisions, to		
	prepare readal	ole documen	tation of	software;	skills in		
	constructively	collaboratin	g with ot	hers in sr	nall teams over	a	
	longer period	of time; abil	ty to clas	sify ones	own results into	o the	
	state-of-the-ar	t of the resp	. area				
Contents							
Prerequisites	none						
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
Format	Lab		8	4	60 T / 210 S	9	
	T = face-to-fa	ce teaching;	S = inde	pendent s	study		
Exam achievements	Oral presentat	ion, written	report		(gra	ided)	
Study achievements		(not graded)					
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						
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		Competences: Application to data science problems and ability						
	to assess similar	to assess similar methods.						
Contents	Data science a	Data science aims at making sense of big data. To that end,						
	various tools have to be understood for helping in analyzing the							
	arising structu	arising structures.						
	Often data con	mes as a colle	ection of	vectors w	ith a large nun	nber		
					structure is th			
	_				a. The geometr			
	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	Avrim Blum, John Hopcroft, and Ravindran Kannan (2018+). Foundations of Data Science.							

Module MA-INF 4229	Pattern Rec	cognition	(1)			
Workload	Credit points	Duration	Freque	ncy		
270 h	9 CP	1 semester				
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		
	clustering, and continuous of implement bases	 devise mathematical models for problems in data analysis, clustering, and classification implement basic and advanced algorithms for model fitting and 				
	optimization• implement bas classification• implement bas					
Soft skills	Students will lea					
	foundations of n				~	l
	learn about basi					
	to implement th					
Contents	• fundamental concepts, prerequisites, and procedures in pattern					
	recognition					
	• basic and adva	_		-		
	• basic and adva	_	_		ry 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, interen	ce, and Lea	rning Algorithm	S

Module	Advanced Methods	of Inform	ation R	etrieval			
MA-INF 4230							
Workload	Credit points Duration	_	-				
180 h	6 CP 1 semester every year						
Module	Prof. Dr. Elena Demidova						
coordinator							
Lecturer(s)	Prof. Dr. Elena Demidova						
Classification	Programme	Mode	Semest				
	M. Sc. Computer Science	_	I		,		
Technical skills	This module introduces data structures, and alg structured and semi-str knowledge graphs, relat	gorithms of in uctured data	nformation (includin	n retrieval for g, for example,			
	At the end of the modu choosing appropriate da	ata structures	and retri	ieval algorithm			
		specific applications and correctly apply relevant statistical and machine learning-based information retrieval procedures.					
Soft skills	Communication skills: oral and written presentation and discussion of solutions.						
	Self-competences: abilit	Self-competences: ability to analyse and solve problems.					
Contents	The module topics include data structures, ranking methods, and efficient algorithms that enable end-users to effectively obtain the most relevant search results from structured, heterogeneous, and distributed data sources. Furthermore, we will study the corresponding evaluation techniques as well as novel applications.						
Prerequisites	none						
Trorequisites	Teaching format	Group size	h/week	Workload[h]	CP		
Format	Lecture	1	2	30 T / 45 S	2.5		
	Exercises		2	30 T / 75 S	3.5		
	T = face-to-face teachir	$\operatorname{ag} S = \operatorname{inder}$	endent st		ı		
Exam achievements	Schriftliche Prüfung	$\log_{10} D = \mathrm{Indep}$	CHacht St		ded)		
Study achievements	Erfolgreiche Übungsteil:	nahme		(not gra			
Forms of media	Errorgreiene Obungstein			(not gra	ucu)		
Torms or media	Selected chapters from:						
	 Christopher D. Manna Schütze, Introduction to University Press. 2008. Bhaskar Mitra and Na Neural Information Ret Information Retrieval: 	ing, Prabhak o Information ick Craswell crieval ", Four	Retrieva (2018), "Andations a	l, Cambridge An Introduction and Trendső in			
Literature	- Ridho Reinanda, Edgar Meij and Maarten de Rijke (2020), "Knowledge Graphs: An Information Retrieval Perspective", Foundations and Trendső in Information Retrieval: Vol. 14: No. 4, pp 289-444.						
	- Jeffrey Xu Yu, Lu Qin, Lijun Chang. Keyword Search in Databases. Synthesis Lectures on Data Management. Morgan & Claypool Publishers. 2009.						
	Further references to rethe lecture.	levant materi	al will be	provided duri	ng		

Module MA-INF 4231	Seminar Ad	lvanced To	pics in I	Informa	tion Retriev	al		
Workload	Credit points	Duration	Frequen	ncy				
120 h	4 CP	1 semester						
Module	Prof. Dr. Eler	na Demidova						
coordinator								
Lecturer(s)	Prof. Dr. Elena Demidova							
CI :C ::	Programme		Mode	Semest	ter			
Classification	M. Sc. Compu	iter Science	Optional	2. or 3	3.			
Technical skills	This module of	This module concentrates on specialized topics in information						
0.6.1.11	study of state- discussion wit audience.							
Soft skills	Communication skills: oral and written presentation of scientific content. Self-competences: the ability to analyze problems, time management, creativity.							
Contents	methods, inclusive process: data ranking, and extrieval meth	Statistical and machine learning-based information retrieval methods, including typical steps of the information retrieval process: data collection, feature extraction, indexing, retrieval, ranking, and evaluation. Specialized data representation and retrieval methods for selected data types and applications in specific domains.						
Prerequisites	Recommended MA-INF 4230		Methods o	of Informa	ation Retrieval			
TD 4	Teaching form	at G	oup size	h/week	Workload[h]	CP		
Format	Seminar		10	2	30 T / 90 S	4		
	T = face-to-fa	ce teaching	S = inden	endent st	audv			
Exam achievements	Oral presentat					ded)		
Study achievements	None	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	100010		(not gra			
Forms of media	110110				(1100 8100	-aca)		
Torms or media	Selected chapt	ers from:						
Literature	 Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Bhaskar Mitra and Nick Craswell (2018), "An Introduction to Neural Information Retrieval ", Foundations and Trendső in Information Retrieval: Vol. 13: No. 1, pp 1-126. 							
	Further relevant literature will be announced at the beginning of the seminar.							

Module MA-INF 4232	Lab Inform	ation Retri	ieval in	Practio	ce			
Workload	Credit points	Duration	Freque	Frequency				
270 h	9 CP	1 semester	every year					
Module	Prof. Dr. Eler	na Demidova		<u> </u>				
coordinator								
Lecturer(s)	Prof. Dr. Elena Demidova							
	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Optiona	al 2. or	3.			
Technical skills	retrieval. Part experience in o	This module concentrates on practical experience in information retrieval. Participants acquire basic knowledge and practical experience in designing and implementing information retrieval systems for specific data types and applications.						
Soft skills	Communication	on skills: the	ability to	o work in	teams.			
	Self-competences: the ability to analyse problems and find practical solutions. Time management, creativity, presentation of results.							
Contents	Practical application of information retrieval methods to solve							
	retrieval problems on real-world data and evaluate proposed							
	solutions.							
Prerequisites	Recommended							
	MA-INF 4230 - Advanced Methods of Information Retrieval							
	MA-INF 4231 Retrieval	- Seminar A	dvanced	Topics in	Information			
T	Teaching forms	at Gro	up size	h/week	Workload[h]	CP		
Format	Lab		8	4	60 T / 210 S	9		
	T = face-to-fa	ce teaching:	S = inde	nendent s	study			
Exam achievements	Oral presentat			pendent		ded)		
Study achievements	None	Jon, Wilden	горого		(not grad			
Forms of media	110110				(Hot Sia	aca)		
1011115 Of filedia	Selected chapt	ers from:						
Literature	 Selected chapters from: Christopher D. Manning, Prabhakar Raghavan and Hinri Schütze, Introduction to Information Retrieval, Cambridge University Press. 2008. Bhaskar Mitra and Nick Craswell (2018), "An Introduction Neural Information Retrieval ", Foundations and Trendső in Information Retrieval: Vol. 13: No. 1, pp 1-126. Further references to relevant material will be provided dur. 							
	the lab.	nces to retera		riai WIII D	c provided durii	ug		

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. Stefan Wrobel						
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 specialize and require in-depth knowledge of one particular class of learning algorithms, they acquire the necessary knowledge to improve existing algorithms and construct their own within the given class, all the way up to the research frontier on the topic.						
Soft skills	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	The module is offered every year, each time concentrating on one or more specific algorithm classes, e.g.						
	 kernel machines neural networks probabilistic and statistical learning approaches logic-based learning approaches reinforcement learning 						
Prerequisites	Recommended all of the follow						
	MA-INF 4111 Machine Learn	_	Learning	and Ana	lysis Systems:		
	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 MA-INF 4303	Learning fro	om Non-S	tandard	Data					
Workload	Credit points	Duration	Freque	ncy					
180 h	6 CP 1 semester every year								
Module	Prof. Dr. Stefan Wrobel								
coordinator									
Lecturer(s)	Prof. Dr. Stefa	an Wrobel,	Dr. Tamas	s Horvath					
Classification	Programme		Mode	Semest	ter				
Classification	-	M. Sc. Computer Science Optional 2. or 3.							
Technical skills	Participants de	-	_		0 0	h			
	_	respect to one particular non-standard data type, i.e.,							
		non-tabular data, as they are becoming increasingly important							
		n many applications. Each type of data not only requires							
		pecialized algorithms but also knowledge of the surrounding							
		re- and postprocessing operations which is acquired by the articipants in the module. In group work, students acquire the							
					_	tne			
		ecessary social and communication skills for effective team vork and project planning, and learn how to present software							
		rojects to others.							
Soft skills			l and writ:	ten presen	tation of solut	ions			
SOIT SKIIIS		Communicative skills (oral and written presentation of solutions, 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		verv vear,	concentra	ting on one				
	particular non-		,		_	t			
	Mining, Multin	media Mini	ig, Graph	Mining. I	Learning from				
	structured dat	a, Spatial I	ata Minin	g					
Prerequisites	Recommended								
	all of the follow	wing:							
	MA-INF 4111	- Intelligen	t Learning	and Ana	lysis Systems:				
	Machine Learr	ning							
	MA-INF 4112	- Intelligen	t Learning	and Ana	lysis Systems:				
	Data Mining a	and Knowle	lge Discov	ery					
	Teaching forms	at C	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	pendent st	udy				
Exam achievements	Written exam					ded)			
Study achievements	Successful exer				(not gra	ded)			
Forms of media	lectures, exerc								
	• Gennady Andrienko, Natalia Andrienko, Exploratory Analysis								
	of Spatial and Temporal Data, Springer, 2006								
	• Diane J. Cook, Lawrence B. Holder, Mining Graph Data,								
T */	Wiley & Sons,		D.l	.:1 D-4	. M::				
Literature	• Saso Dzerosl		vrac, Kela	попаг Dat	a wiming,				
	Springer, 2001 • Sholom M. V		Indurkhy	Tong 71	nang Frad I				
	Damerau, Tex		_	-					
	· ·	_			or rinary 2111g				
	Unstructured Information, Springer, 2004								

Module	Lab Cogniti	ive Roboti			Lab Cognitive Robotics						
MA-INF 4304	Lab Cogini	ive itoboti	CB								
Workload	Credit points	Duration	Freque	ncv							
270 h	9 CP	1 semester	_	emester							
Module	Prof. Dr. Sver		cvery s								
coordinator	Tion Dr. Sver	i Belline									
Lecturer(s)	Prof. Dr. Sver	. Behnke									
Lecturer (5)	Programme	1 Belline	Mode	Seme	ster						
Classification	M. Sc. Compu	iter Science	Optiona								
Technical skills		Participants acquire practical experience and in-depth									
Toominear simils	_		-		of perception a	nd					
	control algorit	_	-								
	group, they an										
	solution, and e										
Soft skills	· ·	Self-competences (time management, goal-oriented work, ability									
	to analyze pro	,				·					
		communication skills (Work together in small teams, oral and									
	written presentation of solutions, critical examination of										
	implementatio	ns)	,								
Contents	Robot middlev	ware (ROS),	$simultan \epsilon$	ous local	lization and						
	mapping (SLA	M), 3D repr	esentation	ns of obje	ects and						
	environments,	object detec	tion and i	recognitio	on, person detec	ction					
	and tracking,	action recogn	ition, act	ion plani	ning and contro	ıl,					
	mobile manipu	ulation, huma	n-robot i	nteractic	on.						
Prerequisites	Recommended	:									
	At least 1 of the	he following:									
	MA-INF 4113	- Cognitive	Robotics								
	MA-INF 4114	– Robot Lea	rning								
	Teaching forma		oup size	h/week	Workload[h]	CP					
Format	Lab		8	4	60 T / 210 S	9					
	T = face-to-fa	ce teaching:	S = inder	endent s	study	1					
Exam achievements	Oral presentat					ded)					
Study achievements		,			(not gra						
Forms of media					, ,						
	• S. Thrun, W	. Burgard ar	d D. Fox	: Probab	ilistic Robotics						
	MIT Press, 20	_									
Literature	• B. Siciliano,	O. Khatib (1	Eds.): Spi	ringer Ha	andbook of						
	Robotics, 2008	3.	, -								
	• Selected rese	• Selected research papers.									

Module	Lab Develo	pment and	Applica	tion o	f Data Minir	ng	
MA-INF 4306	and Learnin	ng Systems	3				
Workload	Credit points	Duration	Frequen	cy			
270 h	9 CP 1 semester every year						
Module	Prof. Dr. Stef	an Wrobel					
coordinator							
Lecturer(s)	Prof. Dr. Stef	Prof. Dr. Stefan Wrobel					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu		Optional	3.			
Technical skills			_	_	the construction		
	•	_		0 0	ms for machine		
	_				work with exis	sting	
	state-of-the-ar	-					
		-	g them for	the req	uirements of th	eir	
	*	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-competences (time management, aiming at long-range goals under limited ressources, ability to work under						
G	pressure, abili	<u> </u>			<u> </u>		
Contents	_	•			llysis. Common		
					of data analysi		
					-processing too ation. Search a		
				_	isualization for	na	
	•					d	
	analysis systems. Data analysis algorithms for embedded and distributed systems. Ubiquitous discovery systems.						
Prerequisites	Recommended		irous disco	overy by	Stellis.		
Tioroquisitos	At least 1 of t						
		_	Loarning	and An	alysis Systems:		
	Machine Learn	_	Dearning	and An	arysis bystems.		
		Ü	Laamina	and And	aleraia Ceratama		
	Data Mining a	_	_		alysis Systems:		
					Worklood [b]	CD	
Format	$\frac{\text{Teaching forms}}{\text{Lab}}$	at Gro	8	$\frac{1/\text{week}}{4}$	Workload[h] 60 T / 210 S	9	
				_	,	9	
	T = face-to-fa			endent s		1 1\	
Exam achievements	Oral presentat	ion, written	report		(0	ided)	
Study achievements	- C	L D		D	(not gra	ided)	
Forms of media	Computer Sof	<u> </u>				C +1	
Literature			be annou	nced tov	wards the end o	i the	
	previous seme	ster.					

Module	Lab Field Programmable Gate Arrays						
MA-INF 4307							
Workload	Credit points	Duration	Freque	ency			
270 h	9 CP	1 semeste	r at leas	at least every 2 years			
Module	Prof. Dr. Joachim K. Anlauf						
coordinator							
Lecturer(s)	Prof. Dr. Joac	Prof. Dr. Joachim K. Anlauf					
Classification	Programme		Mode	Seme	ster		
Classification	M. Sc. Compu	iter Science	Option	al 2. or	3.		
Technical skills	Development a	and simulati	on of digi	tal circui	ts in VHDL and	ł	
	SystemC, expe	SystemC, experience with synthesizable subsets, knowledge of					
	the design pat	the design path from the idea to a realized circuit implemented					
		in an FPGA (field programmable gate array)					
Soft skills		Communicative skills (oral and written presentation of results),					
	,	•			ms, discussions	of	
	solution conce	• /	•		•		
	formulate criti	,	to analy	ze and fir	nd practical		
	solutions to pr						
Contents			_ ′		, and Synthesis		
	•		_		on, and Synthes	sis,	
	Synthesizable	,	st of Impl	ementatio	ons on FPGA		
	Evaluation Bo	ards					
Prerequisites	Recommended	-					
	MA-INF 4207			figurable			
Format	Teaching forms	at Gr	oup size	h/week	Workload[h]	CP	
2 07 11100	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	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	<u>aca</u>
• R. Szeliski: Computer Vision: Algorithms and Application	
Springer 2010.	10,
Literature • C. M. Bishop: Pattern Recognition and Machine Learning	ŗ.
Springer 2006.	17
• NVidia CUDA Programming Guide, Version 4.0, 2011.	

Module MA-INF 4309	Lab Sensor	Lab Sensor Data Interpretation						
Workload	Credit points	Credit points Duration Frequency						
270 h	9 CP 1 semester at least every 2 years							
Module	PD. Dr. Volke	PD. Dr. Volker Steinhage						
coordinator								
Lecturer(s)	PD. Dr. Volke	PD. Dr. Volker Steinhage						
Classification	Programme		Mode	Seme	ster			
Classification	M. Sc. Compu	iter Science	Options	al 2. or	3.			
Technical skills	Competence to	Competence to implement algorithms for sensor data						
	interpretation, efficient handling and testing, documentation.					١.		
Soft skills	Efficient implementation of complex algorithms, abstract							
	thinking, docu	thinking, documentation of source code.						
Contents	Varying selected up-to-date topics on sensor data interpretation							
Prerequisites	Required:							
	All of the follo	owing:						
	MA-INF 2201	- Computer	Vision					
	MA-INF 4206	- Selected 7	Topics in	Sensor Da	ata Interpretation	on		
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	Relevant litera	ture will be	announc	ed at star	t of the lab.			

Module	Lab Mobile	Robots						
MA-INF 4310								
Workload	Credit points	Duration	Frequence	-				
270 h	9 CP	1 semester	at least	every ye	ear			
Module	Prof. Dr. Sver	n Behnke						
coordinator								
Lecturer(s)	Prof. Dr. Sver	n Behnke, Dr.						
Classification	Programme		Mode	Semes				
	M. Sc. Compu		Optional	2. or				
Technical skills	_	_	_	_	actical experience in			
		the design and implementation of control algorithms for simple structured robotic systems using real mobile robots.						
		-	_					
				DOUS WI	ll be identified and			
Soft skills	implemented i			gool ori	iented work, ability			
Soft Skills	to analyze pro	*		_	· · · · · · · · · · · · · · · · · · ·			
			-		l teams, oral and			
	written presen	,	_					
	implementatio		010115, 0110	car caa				
Contents	_		S), robot	simulat	ion tools, basic			
	capabilities for	, –	* *					
	architecture, n				*			
			_		M), visual based			
	object detection			- \	,,			
Prerequisites	Recommended	:						
	At least 1 of the	he following:						
	BA-INF 132 -	Grundlagen	der Robot	ik				
	BA-INF 131 –	Intelligente S	Sehsysteme	е				
	MA-INF 1314							
	MA-INF 2201			0				
		-						
	MA-INF 4113	0						
	MA-INF 4114		_					
	MA-INF 4203				S			
Format	Teaching forma	at Gro		/week	Workload[h] CP			
	Lab		8	4	60 T / 210 S 9			
	T = face-to-fa	ce teaching; S	S = indepe	endent s	study			
Exam achievements	Oral presentat	ion, written r	eport		(graded)			
Study achievements					(not graded)			
Forms of media					ol middleware,			
	_		_		onstration of robot			
	_ `	-	,	esentati	on and written			
	report of appre			D 1 1	III. II. D. J. III.			
			d D. Fox:	Probab	ilistic Robotics.			
	MIT Press, 20		N	. , 11.	D 11: 1 11			
			_	_	nce, Published by			
Literature	Advanced Rob							
	B. Siciliano, Polyation 2008	,	.as.): Spri	nger Ha	andbook of			
	Robotics, 2008		t publicat	iona				
	• Additional S	uate-or-tne-ar	t publicat	ions.				

Module MA-INF 4312	Semantic D	ata Web '	Гесhnolo	gies			
Workload	Credit points	Credit points Duration Frequency					
180 h	6 CP 1 semester every year						
Module	Prof. Dr. Jens Lehmann						
coordinator							
Lecturer(s)		Prof. Dr. Jens Lehmann, Dr. Christoph Lange, Dr. Maria Maleschkova					
Classification	Programme M. Sc. Compu	ProgrammeModeSemesterM. Sc. Computer ScienceOptional1.					
Technical skills			_		re on the		
Toomised same	fundamentals, Web and infor	The goal of this lecture is to impart knowledge on the fundamentals, technologies and applications of the Semantic Web and information retrieval. As part of the lecture the basic concepts and standards for semantic technologies are explained.					
Soft skills							
Contents	technologies had of data, inform standards and applications as projects (e.g. applications surfreebase). The practically oried discussed with RDF syntax • RDF Scheme • ontologies in • RDF databa • Linked Data	As part of the W3C Semantic Web initiative standards and technologies have been developed for machine-readable exchange of data, information and knowledge on the Web. These standards and technologies are increasingly being used in applications and have already led to a number of exciting projects (e.g. DBpedia, semantic wiki or commercial applications such as schema.org, OpenCalais, or Google's Freebase). The module provides a theoretically grounded and practically oriented introduction to this area. The topics discussed within the lecture include: RDF syntax and data model RDF Schema and formal semantics of RDF (S) ontologies in OWL and formal semantics of OWL RDF databases, triple and knowledge stores, query languages Linked Data Web and Semantic Web applications Semantic text analysis and information retrieval systems					
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	Seminar Semantic Data Web Technologies						
MA-INF 4313							
Workload	Credit points	- - · · · · · · · · · · · · · · · ·					
120 h	4 CP 1 semester at least every year						
Module	Prof. Dr. Jens Lehmann						
coordinator							
Lecturer(s)	Dr. Christoph Lange, Dr. Maria Maleshkova						
Classification	Programme	ter					
Classification	M. Sc. Compu	iter Science	Optional	$\lfloor 2.$			
Technical skills	Through the s	eminar, stud	lents will l	earn to w	ork with tools	and	
	technologies of	f the Seman	tic Web as	well as a	ssess their		
	capabilities for	capabilities for given problems. They will gain the ability to					
	understand new research results presented in original scientific						
	papers.						
Soft skills	Ability to pres	Ability to present and to critically discuss technologies and					
	research result	research results in the framework of Semantic Web technologies.					
Contents	• technologies	such as trip	le stores, l	ink discov	very framework	ζs,	
	NLP pipelines						
	• recent confe	rence and jo	urnal pape	ers			
Prerequisites	none						
To 4	Teaching forms	at G	roup size	h/week	Workload[h]	CP	
Format	Seminar		10	2	30 T / 90 S	4	
	T = face-to-fa	ce teaching;	S = indep	endent st	udy		
Exam achievements	Oral presentat	ion, written	report		(gra	ded)	
Study achievements					(not gra	ded)	
Forms of media					-		
Literature							

Module MA-INF 4314	Lab Semantic Data Web Technologies								
Workload	Credit points	Credit points Duration Frequency							
270 h	9 CP 1 semester every year								
Module	Prof. Dr. Jens Lehmann								
coordinator									
Lecturer(s)	Prof. Dr. Jens Lehmann, Dr. Maria Maleschkova								
Classification	Programme		Mode	Seme	ester				
Classification	M. Sc. Compu	iter Science	Option	al 2.					
Technical skills	The students	The students will carry out a practical task (project) in the							
	context of Sen	context of Semantic Web technologies, including test and							
	documentation of the implemented software/system.								
Soft skills	Ability to properly present and defend design decisions, to								
	prepare readal	ole docume	ntation of	software;	skills in				
	constructively	constructively collaborating with others in small 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			
rormat	Lab		8	4	60 T / 210 S	9			
	T = face-to-fa	ce teaching	S = inde	ependent :	study				
Exam achievements	Oral presentat	ion, writter	report		(gra	ided)			
Study achievements					(not gra	ided)			
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						
` ,	Programme Mode Semester						
Classification	M. Sc. Computer Science Optional 2. or 3.						
Technical skills	Ability to understand new research results presented in original scientific papers.						
Soft skills	Ability to present and to critically discuss these results in the framework of the corresponding area.						
Contents	Smart representations (such as embeddings, kernels, and dimensionality reduction methods) are useful models that allow the abstraction of data within a well-defined mathematical formalism. The representations we aim at are conceptual abstractions of real world phenomena (such as social interactions, chemical reactions and biological processes) into the world of statistics and discrete mathematics in such a way that the powerful tools developed in those areas are available for complex analyses in a simple and elegant manner. The focus will be the understanding and comparison of smart						
	representations and their explicit/implicit data transformation models. We will study limitations and advantages of different techniques, and how the data representation changes the problem setup, reduces complexity, introduces robustness, or other valuable properties for big data analytics.						
Prerequisites	Recommended: Open-minded for new problem settings, Programming in different languages (C++, Python, Java), Critical approach to existing solutions, Research curiosity						
Format							
	T = face-to-face teaching; S = independent study						
Exam achievements	Oral presentation, written report (graded)						
Study achievements	(not graded)						
Forms of media							
	[1] Sergey Ivanov, Evgeny Burnaev. "Anonymous Walk Embeddings" ICML, 2018.						
	[2] Tsitsulin, Anton, Davide Mottin, Panagiotis Karras, and Emmanuel Müller "VERSE: Versatile Graph Embeddings from Similarity Measures." WWW, 2018.						
	[3] Yanardag, Pinar, and S. V. N. Vishwanathan. "Deep graph kernels." KDD, 2015.						
Literature	[4] Holger Dell, Martin Grohe, Gaurav Rattan "Lovász Meets Weisfeiler and Leman". ICALP, 2018						
	[5] Anton Tsitsulin, Davide Mottin, Panagiotis Karras, Alexander M. Bronstein, Emmanuel Müller "NetLSD: Hearing the Shape of a Graph". KDD, 2018						
	[6] Nino Shervashidze, Pascal Schweitzer, Erik Jan van Leeuwen, Kurt Mehlhorn, Karsten M. Borgwardt "Weisfeiler-Lehman Graph Kernels". JMLR, 2011						
	[7] Haochen Chen, Bryan Perozzi, Yifan Hu, Steven Skiena "HARP: Hierarchical Representation Learning for Networks". AAAI, 2018.						

Module	Game AI								
MA-INF 4319									
Workload	Credit points	Duration	Freque	ncy					
270 h	9 CP	1 semester	every ye	ear					
Module	Prof. Dr. Chris	tian Bauckha	ge						
coordinator									
Lecturer(s)	Prof. Dr. Chris	tian Bauckha	ge						
Classification	Programme		Mode	Semester					
Classification	M. Sc. Computer Science Optional 2. or 3.								
Technical skills	Upon completion, students should be able to								
	• know about fi	• know about fundamental concepts of artificial intelligence and how							
	they apply to co		-						
	• know about b			nods for pla	nning, problem				
	solving, and bel			· · · ·	G/ I				
			-	thms for pla	anning, problem	L			
	solving, and bel		_	1	O/ 1				
	• implement nu		-	lustering an	d classification				
Soft skills	Students will les	arn about ma	thematica	l and algori	thmic foundatio	ns of			
	artificial intellig	ence. They v	vill learn a	bout basic a	and more advan	ced			
	techniques for p	lanning, prob	olem solvir	ng, and beha	avior modelling,	how			
	to implement th	nem on their	own, and l	now to put	them into practi	ice			
	especially in the	e context of a	rtificial co	mputer gan	ne agents.				
Contents	• historical over	view of game	e AI						
	• basic terms an	nd definitions	for AI in	games					
	• backward ind	uction and th	e minmax	algorithm					
	• alpha-beta pr	-	restircted	searches, fe	atures, and				
	evaluation funct								
	• (traditional, v	,	ree search	algorithms					
	• Monte Carlo t								
	• algorithms for	-	_						
			computer	algorithms i	for data clusteri	ng			
	• self organizing	-		/					
	• finite state ma			- , -					
					g / programming))			
	• probability th			vorks					
	Markov chains	,			11:-				
	hidden Marko Markov dasisi			_					
	• Markov decisi • the Bellman e	-			~				
	• temporal diffe			ieni ieariniiş	3				
	• Q learning	rence tearnin	5						
	• genetic algorit	thms and gen	etic progra	amming					
Prerequisites	Recommended		ette progri						
1 Toroquistos			g knowled	ge in linear	algebra, probab	oility			
	theory, and stat	_	-	_		,1110,			
	Teaching forms		roup size		Workload[h]	CP			
Format	1000000000000000000000000000000000000		1	4	60 T / 105 S	5.5			
	Exercises			2	30 T / 75 S	3.5			
		n tonching: C	= indepen	dont stud-	,	1			
Exam achievements	T = face-to-face Oral exam	e reaching; 5	— maepen	ideni siudy	(,dod)			
		vica participat	ion		, ,,	ided)			
Study achievements	Successful exerc			no	(not gra	iueu)			
	■ Locture alidea		пале ОШП	IIC					
Forms of media	• lecture slides			nnles are m	ade available on	lino			
	• lecture notes	with program	ıming exar		ade available on	line			
Forms of media	• lecture notes Russell and Nor	with program vig, "Artificia	aming exar	nce: A Mod		line			
	• lecture notes	with program vig, "Artificia	aming exar	nce: A Mod		line			

Module MA-INF 4320	Lab Representation Learning on Graphs							
Workload	Credit points	Credit points Duration Frequency						
270 h	9 CP 1 semester every year							
Module	Prof. Dr. Emmanuel Müller							
coordinator								
Lecturer(s)	Prof. Dr. Emmanuel Müller							
Classification	Programme		N	/Iode	Seme	ster		
Classification	M. Sc. Compu	iter Scienc	e C	Optiona	d 2. or	3.		
Technical skills	The students	The students will carry out a practical task (project) in the						
	context of repr	context of representation learning on graphs, including test and						
	documentation of the implemented software/system.							
Soft skills	Ability to properly present and defend design decisions, to							
	prepare readal	ole docum	entat	ion of	software;	skills in		
	constructively	constructively collaborating with others in small teams over a						
	longer period	of time; ab	oility	to clas	sify ones	own results into	o the	
	state-of-the-ar	t of the re	sp. a	rea				
Contents								
Prerequisites	none							
Format	Teaching forms	at (Group	size	h/week	Workload[h]	CP	
rormat	Lab		8	3	4	60 T / 210 S	9	
	T = face-to-fa	ce teachin	g; S =	= inde	pendent s	study		
Exam achievements	Oral presentat	ion, writte	en rej	port		(gra	ided)	
Study achievements						(not gra	ided)	
Forms of media								
Literature								

Module MA-INF 4321	Seminar Learning from Time Series						
Workload	Credit points Duration Frequency						
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Emn	Prof. Dr. Emmanuel Müller					
coordinator							
Lecturer(s)	Prof. Dr. Emm	nanuel Mülle	er				
Classification	Programme		Mode	Semest	ter		
Classification	M. Sc. Compu	ter Science	Optional	2. or 3	3.		
Technical skills	Ability to understand new research results presented in original					inal	
	scientific papers.						
Soft skills	Ability to prese	Ability to present and to critically discuss these results in the					
	framework of t	he correspor	ding area				
Contents	Current conference	ence and jou	rnal pape	rs			
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 = 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 MA-INF 4323	Pattern Recognition	on (2)						
Workload	Credit points Duratio	n Freque	ncy					
270 h	9 CP 1 semes	ter every ye	ear					
Module	Prof. Dr. Christian Bauc	khage						
coordinator								
Lecturer(s)	Prof. Dr. Christian Bauc	khage						
Classification	Programme	Mode	Semester					
Classification	M. Sc. Computer Science	_	2. or 3.					
Technical skills	Upon completion, studen	ts should be a	able to					
	• know about aspects of numerical computing and how these may affect practical implementations of machine learning / pattern recognition algorithms							
	• know about iterative al	gorithms for a	machine lea	rning / pattern				
	recognition with large da	~		8 / F				
	• implement numerically robust algorithms for data dimensionality							
	reduction	O						
	• implement numerically	robust data o	lustering ar	nd classification				
Soft skills	Students will learn about	mathematica	l and algori	ithmic foundation	ns o			
	robust implementations of							
	analysis and pattern reco							
	algorithms and dynamica	l systems app	roaches in t	this area, how to)			
	implement them on their			em into practice.				
Contents	• advanced concepts from	_						
	• QR-, spectral-, and sing							
	• iterative algorithms for	-	-					
	• iterative algorithms for		-	*				
	• Hebbian learning and ()ja's rule for j	principal co	mpoentn analys:	lS			
	• auto-encoder networks	1						
	associative memory net	WORKS						
	Hopfield networksHopfield networks for p	attorn rocorn	ition					
	Hopfield networks for p Hopfield networks for p	9						
	• energy minimization me		~	ng and nattern				
	recognition	00110 00 111 11100	711110 10011111	as and partern				
	• latent factor models for	data analysis	8					
	• data matrix factorization							
	• multidimensional scalin	g						
	• manifold learning							
	• basic graph theory							
	• graph cuts and graph c	lustering						
	• graph diffusion processe							
	• radial basis functions for							
	• radial basis functions for							
	• radial basis functions for	or density esti	mation					
Prerequisites	Recommended:							
	Students should good wo	-	-		oility			
	theory, and statistics. Ide	eally, they wil	I have atten	ided the lecture				
	Pattern Recognition (1).	G :	1. / 1	XX711 1511				
To wood	Teaching format	Group size		Workload[h]	CI			
Format	Lecture Exercises		$\begin{vmatrix} 4\\2 \end{vmatrix}$	60 T / 105 S	$\begin{vmatrix} 5.5 \\ 3.5 \end{vmatrix}$			
			1	30 T / 75 S	0.6			
_	T = face-to-face teaching	S = independent S = independ	ndent study					
Exam achievements	Schriftliche Prüfung	,			aded			
Study achievements	Erfolgreiche Übungsteilna			(not gra	aded			
Forms of media	• lecture slides are made			1 .1.1.1	1.			
	• lecture notes with prog							
	MacKay, "Information Th				S"			
	Haykin, "Neural Network	s and Learnin	g Machines	, "				
	Bishop, "Neural Networks	s for Pattern	Recognition	. "				
Literature	Elden, "Matrix Methods:		_		"			
	Liden, manix methods	m Data Milli	ig anu ratt	CITI I GCOSIII (1011				
	C1 -11	0 1 -	, , ,					

Skillicorn, "Understanding Complex Datasets"

Module	Seminar Ad	lvanced T	opics in I	Data Sc	ience		
MA-INF 4324							
Workload	Credit points Duration Frequency						
120 h	4 CP 1 semester every year						
Module	Prof. Dr. Elena Demidova						
coordinator							
Lecturer(s)	Prof. Dr. Elena Demidova						
Classification	Programme M. Sc. Compu	Programme Mode Semester M. Sc. Computer Science Optional 2. or 3.					
Technical skills	This module of The students of state-of-the-ar	This module concentrates on specialized topics in data science. The students obtain skills in the independent, in-depth study of state-of-the-art scientific literature on specific topics, discussion with their peers and presentation to the scientific audience.					
Soft skills	scientific conte	 Communication skills: oral and written presentation of scientific content. Self-competences: the ability to analyze problems, time management, creativity. 					
Contents	analytics, includata generation and evaluation	Statistical and machine learning-based methods of data analytics, including typical steps of the data science process: data generation, integration, cleaning, exploration, modelling and evaluation. Specialized data representation and analytics methods for selected data types and applications in specific					
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 Science in Practice					
MA-INF 4325						
Workload	Credit points	Duration	Frequ	ency		
270 h	9 CP	1 semest		every year		
Module	Prof. Dr. Elena Demidova					
coordinator						
Lecturer(s)	Prof. Dr. Elena Demidova					
Classification	Programme		Mode	Seme	ster	
Classification	M. Sc. Computer Science		e Option	al 2. or	3.	
Technical skills	This module c	oncentrate	s on pract	ical exper	ience in data	
	analytics. Participants acquire basic knowledge and practical					
	experience in the design and implementation of data science					
	workflows for specific data types and applications.					
Soft skills	Communicate	tion skills:	the ability	to work	in teams.	
	• Self-competences: the ability to analyse problems and find					
	practical solutions. Time management, creativity, presentation					
	of results.					
Contents	Practical application of statistical and machine learning-based					
	methods to solve data analytics problems on real-world datasets					
	and evaluate proposed solutions.					
Prerequisites	Recommended:					
	BA-INF 150 - Einführung in die Data Science					
	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-face teaching; $S = independent study$					
Exam achievements	Oral presentation, written report				(gra	ded)
Study achievements	None				(not graded)	
Forms of media						
Literature						

5 Master Thesis

MA-INF 0401	30 CP	Master Thesis	148
MA-INF 0402	2 CP	Master Seminar	149

Module MA-INF 0401	Master The	sis					
Workload	Credit points	Duration	Freque	ncy			
900 h	30 CP	1 semeste	ester every semester				
Module			<u>'</u>				
coordinator							
Lecturer(s)	All lecturers of computer science						
Classification	Programme		Mode	Se	Semester		
Classification	M. Sc. Compu			ulsory 4.			
Technical skills	Ability to solve a well-defined, significant research problem under supervision, but in principle independently						
Soft skills	Ability to write a scientific documentation of considerable length according to established scientific principles of form and style, in particular reflecting solid knowledge about the state-of-the-art in the field						
Contents	Topics of the thesis may be chosen from any of the areas of						
	computer science represented in the curriculum						
Prerequisites	none	none					
	Teaching format		Froup size	h/week		CP	
Format	Independent preparation of scientific thesis individual coad	s with		0	900 S	30	
	T = face-to-face teaching; S = independent study						
Exam achievements	Master Thesis (graded)						
Study achievements	(not graded)						
Forms of media							
Literature	Individual bibliographic research required for identifying relevant literature (depending on the topic of the thesis)						

Module MA-INF 0402	Master Seminar					
Workload	Credit points Duration Frequency					
60 h	2 CP	1 semester				
Module	_	77 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7				
coordinator						
Lecturer(s)	All lecturers of computer science					
Classification	Programme		Mode Semester		mester	
	M. Sc. Computer Science Compulsory			sory 4.	4.	
Technical skills	Ability to document and defend the results of the thesis work in					
	a scientifically appropriate style, taking into consideration the					
	state-of-the-art in research in the resp. area					
Soft skills						
Contents	Topic, scientific context, and results of the master thesis					
Prerequisites	none					
T	Teaching forms	at G	roup size	h/week	Workload[h]	CP
Format	Seminar			2	30 T / 30 S	2
	T = face-to-face teaching; $S = $ independent study					
Exam achievements	Oral presentation of final results (graded)					
Study achievements	(not graded)					
Forms of media						
T *4	Individual bibliographic research required for identifying					
Literature	relevant literature (depending on the topic of the thesis)					