Module Handbook

for the

Master Programme "Computer Science"

at

Rheinische Friedrich-Wilhelms-Universität Bonn

(revised version: March 31, 2008)

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. The respective blocks start on the pages given below.

1. Algorithmics	3
2. Graphics, Vision, Audio	25
3. Information and Communication Management	41
4. Intelligent Systems	63
Master Thesis & Seminar	83

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

- **A** = number of the area of competence
- **S** = 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 1^{st} and the 3^{rd} semester. The 4^{th} semester is reserved for preparing the master thesis.

Module Handbook

Master Programme "Computer Science"

Area of Competence

Algorithmics

MA-INF 1101	14F2	8 CP	Pearls of Algorithms	NB
MA_INE 1102			Combinatorial Ontimization	
				JV
MA-INF 1103	L4E2	8 CP	Cryptography	JG
MA-INF 1201	L4E2	8 CP	Approximation Algorithms for NP-Hard Problems	MK
MA-INF 1202	L4E2	8 CP	Chip Design	JV
MA-INF 1203	L4E2	8 CP	Discrete and Computational Geometry	RoK
MA-INF 1204	Sem	4 CP	Seminar Selected Topics in Information and	NB
			Learning Theory	
MA-INF 1205	Sem	4 CP	Seminar Discrete Optimization	JV
MA-INF 1206	Sem	4 CP	Seminar Design and Analysis of Randomized and	MK
			Approximation Algorithms	
MA-INF 1207	Lab	8 CP	Lab Combinatorial Algorithms	JV
MA-INF 1208	L4E2	8 CP	Applications of Cryptography	JG
MA-INF 1301	L4E2	8 CP	Algorithmic Game Theory and the Internet	MK
MA-INF 1302	L4E2	8 CP	Advanced Topics in Algorithmics	MK
MA-INF 1303	L2V1	4 CP	Selected Topics in Algorithmics	NB
MA-INF 1304	Sem	4 CP	Seminar Geometric Distance Problems	RoK
MA-INF 1305	Sem	4 CP	Seminar Chip Design	JV
MA-INF 1306	Sem	4 CP	Seminar Combinatorial and Geometric Optimiza-	MK
			tion	
MA-INF 1307	Sem	4 CP	Seminar Advanced Algorithms	MK
MA-INF 1308	Lab	8 CP	Lab Algorithms for Chip Design	JV
MA-INF 1309	Lab	8 CP	Lab Efficient Algorithms for Selected Problems:	MK
			Design, Analysis and Implementation	

(L: Lecture, E: Exercise, Sem: Seminar)

Module coordinators:

Norbert Blum (NB), Marek Karpinski (MK), Rolf Klein (RoK), Jens Vygen (JV), Joachim von zur Gathen (JG)

Module name: Pearls of Algorith	ıms				universitä	it bonn
Module No. MA-INF 1101	Workload 240 h	Credit points 8		Frequ Every	ency year	
Module coordinator	Prof. Dr. Norbert B	lum				
Lecturer(s)	Prof. Dr. Norbert B	lum, Prof. Dr. Ma	arek Kar	pinski,	Prof. Dr. Ro	olf Klein
Classification	Progran	nme	Compu Opti	ilsory/ onal	Semes	ster
	M.Sc. Computer Sc	cience	Option	al	1 st sem.	
Targeted learning outcomes	technical skills: Deeper insights in algorithmics <u>soft skills</u> : Presentation of s applied methods ar	technical skills: Deeper insights into selected methods and techniques of modern algorithmics <u>soft skills</u> : Presentation of solutions and methods, critical discussion of				
Contents	Selected state of the topics include proximate algorithe torial optimization.	ne-art topics of m advanced data s ms, problems of	nodern a structure discrete	ilgorith es, effic e geom	mics. In par cient exact a netry and co	rticular, and ap- ombina-
Prerequisites	None					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Lecture60460 T/90 SExercises30230 T/60 S(Individual solving of problems in small groups, presentation and dis- subtraction in the relation302					5 3
Exam achievements	, ,	Exam	ו(s)			
(graded)	Written exam					
Study achievements (not graded)	Successful exercise participation					
Forms of media						
Literature	Depending on the t vant research litera resp. semester.	opics varying fro ture will be anno	m seme ounced b	ster to efore t	semester, th he start of t	ne rele- ne

Module name: Combinatorial Optin	Module name: Combinatorial Optimization				universitä	tbonn
Module No. MA-INF 1102	Workload 240 h	Credit poir 8	nts	Frequenc At least o	y every year	
Module coordinator	Prof. Dr. Jens Vygen	I		1		
Lecturer(s)	Prof. Dr. Norbert Blur Prof. Dr. Marek Karpi Junior-Prof. Dr. Tim N	n, Prof. Dr nski, Prof. lieberg, Pr	. Ste Dr. of. E	efan Houg Bernhard Dr. Jens V	ardy, Korte, ygen	
Classification	Programme	Compuls	sory	/ Optional	Semes	ter
	M.Sc. Computer Science	Optional			1 st or 2 nd s	em.
Targeted learning out- comes	<u>technical skills</u> : Advanced knowledge of combinatorial optimization. Modelling and development of solution strategies for combinatorial optimization problems <u>soft skills</u> : Mathematical modelling of practical problems, abstract thinking,					
Contents	Matchings, b-matchir submodular function polyhedral combinato	ngs and T- minimizat rics. NP-ha	join: ion, ard i	s, optimiz travelling problems	zation over ma g salesman pr	atroids, oblem,
Prerequisites	None	/				
Format/workload/ credits	Teaching format	Grou size	e dr	Hours/ week	Workload [h]	Credits
	Lecture Exercises	60 30))	4 2	60 T/90 S 30 T/60 S	5 X
Exam achievements		Exa	am(s	5)		
(graded)	Written exam					
Study achievements (not graded)	Successful exercise	participat	tion			
Forms of media						
Literature	 B. Korte, J. Vygen: Corithms. Springer, 4th A. Schrijver: Combination Springer 2003 W. Cook, W. Cunning Combinatorial Optim 	ombinatoria edition, 20 atorial Optir ham, W. Pu ization. Wile	ll Op 08 niza lleyt ey 19	timization: tion: Polyh plank, A. So 997	Theory and Alg edra and Efficie chrijver:	o- ncy.

Module name:						A I	
Cryptography				universitätbonn			
Module No. MA-INF 1103	Workload 240 h	Credit p 8	oints	Frequency Every year			
Module coordinator	Prof. Dr. Joachim	on zur (Gathen				
Lecturer(s)	Prof. Dr. Joachim	/on zur (Gathen				
Classification	Programme		Compul	sory/ Optional	Semes	ter	
	M.Sc. Computer Sc	cience	Optiona	il	1 st or 3 rd se	m.	
Targeted learning outcomes	technical skills: Understanding of s play between com ments. Mastery of analysis <u>soft skills</u> : Oral presentation cise solutions), te critical assessment	technical skills: Understanding of security concerns and measures, and of the inter- play between computing power, key length, and security require- ments. Mastery of the basic techniques for cryptosystems and crypt- analysis <u>soft skills</u> : Oral presentation (in tutorial groups), written presentation (of exer- cise solutions), team collaboration in solving homework problems,					
Contents	Basic private-key based. Security re tions, signatures, ging; lower bounds	and pul ductions identific in struc	blic-key o s. Key ex ation; fa ctured mo	cryptosystems change, crypt ctoring intege odels	: AES, RSA, ographic has rs and discre	group- h func- ete log-	
Prerequisites	None						
Format/workload/ credits	Teaching form	nat	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises		60 30	4 2	60 T/90 S 30 T/60 S	5 3	
Exam achievements			Exan	n(s)		•	
(graded)	Written exam (oral	exam ir	i exceptic	onal cases)			
Study achievements (not graded)	Successful exercise	e partici	pation				
Forms of media							
Literature	Course notesStinson, Cryp	otograph	iy: Theory	y and Practice	, 2 nd edition		

Module name: Approximation Algorithms for NP-Hard Problems					universitätbonn		
Module No. MA-INF 1201	Workload 240 h	Credit points 8		Frequ At lea	Frequency At least every year		
Module coordinator	Prof. Dr. Marek K	Carpinski					
Lecturer(s)	Prof. Dr. Norbert Prof. Dr. Bernhar	Blum, Prof. Dr. d Korte, Prof. Dr	Marek Ka ^r . Jens Vy	rpinsk gen, N	i, Prof. Dr. R .N.	olf Klein,	
Classification	Progra	mme	Compu Optic	sory/ nal	Seme	ster	
	M.Sc. Computer	Science	Optiona		2 nd or 3 rd s	em.	
Targeted learning outcomes	technical skills: Introduction to d algorithms for N various technique methods and app <u>soft skills</u> : Presentation of applied methods	technical skills: Introduction to design and analysis of most important approximation algorithms for NP-hard combinatorial optimization problems, and various techniques for proving lower and upper bounds, probabilistic methods and applications <u>soft skills</u> : Presentation of solutions and methods, critical discussion of explicit methods and techniques					
Contents	Approximation Algorithms and Approximation Schemes. Design and Analysis of Approximation algorithms for selected NP-hard problems, like Set-Cover, and Vertex-Cover problems, MAXSAT, TSP, Knapsack, Bin Packing, Network Design, Facility Location. Introduction to various approximation techniques (like Greedy, LP-Rounding, Primal-Dual, Local Search, randomized tech- niques and Sampling, and MCMC-Methods), and their applications. Analysis of approximation hardness and PCP-Systems						
Prerequisites	Introductory know theory is essentia	wledge of founda al.	tions of a	lgorith	ms and com	plexity	
Format/workload/ credits	Teaching	g format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises (Individual solving small groups, pres cussion in tutorials	of problems in entation and dis- ;)	60 30	4 2	60 T/90 S 30 T/60 S	5 3	
Exam achieve- ments		Ex	kam(s)				
(graded)	Oral exam						
Study achieve- ments (not graded)	Successful exerci	se participation					
Literature	S Arora C Lui	nd: Hardness of A	nrovimati	one In	Annrovimatic		
	 S. Arora, C. Lul rithms for NP-F M. Karpinski: R Berechnungspr 2007 B. Korte, J. Vyg (4th edition), Spring V. V. Vazirani: J 	and Problems (D. Randomisierte und robleme, Lecture N gen: Combinatoria ger, 2008 <u>Approx</u> imation Alg	S. Hochba approxim lotes (5th l Optimiza	ative Al edition tion: Th	d.), PWS, 1996 gorithmen für), Universität E neory and Algo	harte 30nn, rithms	

Module name:						A
Chip Design					universitä	itbonn
Module No. MA-INF 1202	Workload 240 h	Credit points 8		Frequ Every	iency / year	
Module coordinator	Prof. Dr. Jens Vyge	en				
Lecturer(s)	Prof. Dr. Stefan Ho Junior-Prof. Dr. Tir	ougardy, Prof. Dr n Nieberg, Prof.	r. Bernharo Dr. Jens \	d Korte /ygen	2,	
Classification	Progran	nme	Compul Optio	sory/ nal	Semes	ster
	M.Sc. Computer So	cience	Optional		2 nd sem.	
l argeted learning outcomes	technical skills: Knowledge of the central problems and algorithms in chip design. Competence to develop and apply algorithms for solving real-world problems, also with respect to technical constraints. Techniques to develop and implement efficient algorithms for very large instances. <u>soft skills</u> : Mathematical modelling of problems occurring in chip design, development of efficient algorithms, abstract thinking, presentation of solutions to express				design. al-world ques to nces. design, ation of	
Contents	Problem formulation placement, routing	on and design fl g, timing analys	ow for chi sis and op	p desig timiza	gn, logic syr tion, clockt	nthesis, ree de-
	sign					
Prerequisites	None			1		
credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercises		60 30	4 2	60 T/90 S 30 T/60 S	5 3
Exam achievements		Exa	m(s)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 As long as no record will be used. The for ences to individual C.J. Alpert, D.P. rithms for VLSI appear B. Korte, D. Rau vation for layout ings of the IEEE 	mmendable liter ollowing sources topics: Mehta, S.S. Sap Physical Design tenbach, J. Vyge and timing clos , 95 (2007), 555	ature is av provide a patnekar: ⁻ Automatic en: BonnTo sure of syst 5-572	vailable range The Ha on. Tay pols: M tems o	e, a lecture s of relevant i ndbook of A lor and Frar lathematical n a chip. Pr	script refer- ligo- ncis, to l inno- oceed-

Module name: Discrete and Cor	nputational Geom	etry			universitä	tbonn
Module No. MA-INF 1203	Workload 240 h	Credit points 8		Frequ Every	iency / 2 years	
Module coordinator	Prof. Dr. Rolf Klein					
Lecturer(s)	Prof. Dr. Norbert E Prof. Dr. Rolf Klein	Blum, Prof. Dr. N	larek Karp	inski,	_	
Classification	Progran	nme	Compuls Optior	sory/ nal	Semes	ster
	M.Sc. Computer Se	cience	Optional		2 nd sem.	
Targeted learning outcomes	technical skills: To acquire insigh problems; to be al gorithms <u>soft skills</u> : Presentation of ov cussion of applied	<u>technical skills</u> : To acquire insight into the combinatorial complexity of geometric problems; to be able to use this knowledge in developing efficient al- gorithms <u>soft skills</u> : Presentation of own and others solutions methods and critical dis-				
Contents	We study in lowe grams, arrangem quences, visibility, In higher dimensi convex hulls, range ties, lattices, VC-di	r dimensions c ents, lower e and path planni ons we conside e queries, dimer mension, and er	oncrete ar nvelopes, ng probler r geometr nsion reduc osilon-nets	nd abs Dave ns. ic net ction,	stract Voror nport-Schinz work constr geometric ir	ioi dia- zel se- ruction, nequali-
Prerequisites	None					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Lecture Exercises (Individual solving of small groups)	f problems in	60 30	4 2	60 T/90 S 30 T/60 S	5 3
Exam achievements		Exa	m(s)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise participation					
Forms of media						
Literature	 Matousek, Lecture Narasimhan/Smie Klein, Concrete ar 	es on Discrete Geo d, Geometric Spar nd Abstract Voron	ometry nner Networ oi Diagrams	ks S		

Module name: Seminar Selected Theory	d Topics in Inform	ation and Learn	ing		universitä	tbonn
Module No. MA-INF 1204	Workload 120 h	Credit points 4		Freque At leas	ncy st every 2 y	ears
Module coordinator	Prof. Dr. Norbert B	lum				
Lecturer(s)	Prof. Dr. Norbert B	lum				
Classification	Progran	nme	Compul Optic	lsory/ nal	Semes	ster
	M.Sc. Computer Sc	cience	Optiona	1	2 nd sem.	
Targeted learning outcomes	Ability to perform i standing, and clear	ndividual literatu [·] didactic present	ire searc tation	h, critic	al reading,	under
Contents	Advanced topics in research literature	information and	learning	theory	based on I	nodern
Prerequisites	None			-		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T / 90 S	4
Exam achievements		Exam	ו(s)	1		
(graded)	Oral presentation					
Study achievements (not graded)	Regular participation, written report					
Forms of media						
Literature	The relevant literat vious semester.	ure will be annou	inced tow	vards th	ne end of th	e pre-

Module name: Seminar Discrete	e Optimization				universitä	tbonn
Module No. MA-INF 1205	Workload 120 h	Credit points 4		Frequ Every	ency year	
Module coordinator	Prof. Dr. Jens Vyge	n				
Lecturer(s)	Prof. Dr. Stefan Ho Junior-Prof. D. Tim	ugardy, Prof. Dr. Nieberg, Prof. D	Bernhar <u>Pr. Jens V</u>	d Kort ygen	e,	
Classification	Program	nme	Compul Optio	sory/ nal	Semes	ster
	M.Sc. Computer Sc	cience	Optiona		2 ^{na} sem.	
outcomes	<u>tecnnical skills</u> : Competence to understand new research results based on original literature, to put such results in a broader context and present such results and relations. <u>soft skills</u> : Ability to read and understand research papers, abstract thinking, presentation of mathematical results in a talk					
Contents	A current research semester and discu	topic in discrete issed based on o	optimiza riginal lit	tion w eratur	vill be choser re.	n each
Prerequisites	<u>Required</u> : Combinatorial Opti	mization (MA-INI	F 1102)			
Format/workload/ credits	Teaching	format	Group size	Hour s/we ek	Workload [h]	Credits
	Seminar		10	2	30 T / 90 S	4
Exam achievements		Exam	n(s)	I		
(graded)	Oral presentation					
Study achievements (not graded)	Regular participation, written report					
Forms of media						
Literature	The topics and the end of the previous	relevant literatur semester.	e will be	annoi	unced toward	ds the

Module name:						A
Seminar Design a Approximation Alg	nd Analysis of Ra gorithms	andomize	d and		universitä	ät bonn
Module No. MA-INF 1206	Workload 120 h	WorkloadCredit pointsFrequency120 h4Every year				
Module coordinator	Prof. Dr. Marek K	Karpinski				
Lecturer(s)	Prof. Dr. Marek K	Carpinski				
Classification	Programme	Programme Compulsory/ Op			Semester	
	M.Sc. Computer Science	Option	al		2 nd sem.	
Targeted learning outcomes	Ability to perforr derstanding, and	n individua clear dida	al literat ctic pres	ure sea sentatior	rch, critical read า	ing, un-
Contents	Current topics approximation al	in desig gorithms b	n and ased on	analysi lastest	s of randomize research literatur	ed and e
Prerequisites	None					
Format/workload/ credits	Teaching fo	rmat	Group size	Hours week	Workload [h]	Credits
	Seminar		10	2	30 T / 90 S	4
Exam achievements (graded)	Oral presentatior	1	Exam	(s)		
Study achievements (not graded)	Regular participation, written report					
Forms of media						
Literature	The relevant liter	ature will b	e annou	inced in	time.	

Module name: Lab Combinator	ial Algorithms				universitä	tbonn
Module No. MA-INF 1207	Workload 240 h	Credit points 8		Frequency Every yea	/ ar	
Module coordinator	Prof. Dr. Jens Vyg	en				
Lecturer(s)	Prof. Dr. Stefan Ho Junior-Prof. Dr. Ti	ougardy, Prof. D m Nieberg, Prof	r. Bern . Dr. Je	hard Kort ns Vygen	te,	
Classification	Prograr	nme	Com Op	pulsory/ tional	Semest	er
	M.Sc. Computer S	cience	Optio	nal	2 nd sem.	
outcomes	<u>technical skills</u> : Competence to implement advanced combinatorial algorithms, han- dling nontrivial data structures, testing, documentation. Advanced software techniques. <u>soft skills</u> : Efficient implementation of complex algorithms, abstract thinking, documentation of source code					
Contents	Certain combinate precise task will b	orial algorithms e explained in a	will be meetin	e chosen g in the p	each semesto previous seme	er. The ster.
Prerequisites	<u>Required</u> : Combinatorial Opt	imization (MA-I	NF 110	2)		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lab		8	2	30 T/210 S	8
Exam achievements		Ex	am(s)			
(graded)	Oral presentation					
Study achieve- ments (not graded)	Regular participation, software documentation					
Forms of media						
Literature	The topics and the end of the previou	e relevant literat s semester	ure will	be annou	unced towards	s the

Module name:						A	
Applications of C	Cryptography			universität bonn			
Module No. MA-INF 1208	Workload 240 h	Credit points 8	Frequency Every year				
Module coordinator	Prof. Dr. Joachim	von zur Gathen					
Lecturer(s)	Prof. Dr. Joachim	von zur Gathen,	Dr. Micha	ael Nüsl	ken		
Classification	Progran	nme	Compu Optic	lsory/ onal	Semes	ster	
	M.Sc. Computer Se	cience	Optiona	I	2 nd sem.		
Targeted learning outcomes	technical skills: Understanding, me quirements in tran and their potential <u>soft skills</u> : Oral presentation cise solutions), te critical assessmen	technical skills: Understanding, modelling and differentiating the various security re- quirements in transaction schemes. Overview of cryptographic tools and their potential applications. Learning about success and pitfalls. <u>soft skills</u> : Oral presentation (in tutorial groups), written presentation (of exer- cise solutions), team collaboration in solving homework problems, critical assessment					
Contents	The tools of crypt internet security, e ports and health c be of current conce	The tools of cryptography are applied to various application areas: internet security, electronic cash, elections and auctions, digital pass- ports and health cards. The topics may vary and are often chosen to be of current concern or students' interest					
Prerequisites	<u>Recommended</u> : Cryptography (MA·	INF 1103)					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises		60 30	4 2	60 T/90 S 30 T/60 S	5 3	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Written exam (oral exam in exceptional cases) Successful exercise participation						
Forms of media							
Literature	 Course notes Stinson, Cryp 	s otography: Theol	ry and Pr	actice, :	2 nd edition		

Module name:						A	
Algorithmic Gam	e Theory and t	he Internet		universität bonn			
Module No.	Workload	Credit points		Frequency			
MA-INF 1301	240 h	8		Every 2 ye	ears		
Module coordinator	Prof. Dr. Marek	Prof. Dr. Marek Karpinski					
Lecturer(s)	Prof. Dr. Norbert	Blum, Prof. Dr. Mar	rek Karp	oinski	1		
Classification	Prog	gramme	Con O	npulsory/ ptional	Semes	ter	
	M.Sc. Computer	Science	Optior	nal	2 nd or 3 rd se	em.	
l argeted learning outcomes	technical skills: The goal is to p Theory for analy for designing alg resource allocat auctions, and the soft skills: Presentation of applied methods	technical skills: The goal is to provide basic techniques and methods related to the Game Theory for analyzing modern Internet-based communication networks and for designing algorithms for the underlying problems of transmission control, resource allocation, mechanism design, market equilibria, combinatorial auctions, and the network cost allocation <u>soft skills</u> : Presentation of solutions and methods, critical discussion of					
Contents	The most definin a single central individual entitie providers, design basic techniques Internet-related to the Internet mechanism design natorial auctions We will address r emerged recently digms in design Introductory kno	The most defining characteristic of the Internet 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, combi- natorial auctions, cost allocations and network design. We will address new broadly applicable and unifying techniques that have emerged recently in the above areas and discuss new fundamental para- digms in design of the relevant algorithms.					
Format/workload/	is essential.	ing format	Group	Hours/	Warklood [b]	Cradita	
credits	reach	ing iorriat	size	week		Credits	
	Lecture Exercises (Individual solvin small groups, pr cussion in tutoria	g of problems in esentation and dis- als)	60 30	4 2	60 T/90 S 30 T/60 S	5 3	
Exam achievements		Exa	am(s)				
(graded)	Oral exam						
(not graded)	Successful exerc	ise participation					
Forms of media							
Literature	 D. P. Bertsekas, A. Nedic, A. E. Ozdaglar: 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 Univ. Press, 1990 N. Nisan, T. Roughgarden, E. Tardos, V.V. Vazirani (ed.): Algorithmic Game Theory, Cambridge Univ. Press, 2007 						

Module name: Advanced Topics in Algorithmics				universitätbonn			
Module No. MA-INF 1302	Workload 240 h	Credit points 8		Frequer At leas	ncy t every 2 yea	ars	
Module coordinator	Prof. Dr. Marek Ka	rpinski					
Lecturer(s)	Prof. Dr. Norbert B Prof. Dr. Marek Ka	Blum, Prof. Dr. Jo rpinski, Prof. Dr	oachim vo . Rolf Kle	on zur (in, Prof	Gathen, . Dr. Nitin Sa	axena	
Classification	Progran	nme	Compu Optio	ilsory/ onal	Semes	ster	
	M.Sc. Computer So	cience	Optiona		2 nd or 3 rd	sem.	
Targeted learning outcomes	technical skills: Introduction to cu search <u>soft skills</u> : Presentation of applied methods a	technical skills: Introduction to current advanced research topics in algorithmic re- search <u>soft skills</u> : Presentation of solutions and methods, critical discussion of applied methods and techniques					
Contents	The topic will be announced before the start of the relevant semester.						
Prerequisites	Introductory knowl theory is essential.	edge of foundati	ions of al	gorithm	s and comp	lexity	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises (Individual solving of small groups, preser cussion in tutorials)	problems in Itation and dis-	60 30	4 2	60 T/90 S 30 T/60 S	5 X	
Exam achievements		Exa	m(s)				
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media							
Literature	Depending on the t vant research litera semester.	topics varying fro ature will be ann	om seme ounced b	ster to s efore th	semester, th ne start of th	e rele- le resp.	

Module name: Selected Topics in Algorithmics					universitä	tbonn
Module No. MA-INF 1303	Workload 120 h	Credit points 4		Frequen At least	cy every 2 year	rs
Module coordinator	Prof. Dr. Norbert B	lum				
Lecturer(s)	Prof. Dr. Norbert B	lum, Prof. Dr. M	larek Ka	arpinski,	Prof. Dr. Ro	lf Klein
Classification	Progran	Programme		ulsory/ ional	Semester	
	M.Sc. Computer Sc	cience	Optior	nal	2 nd or 3 rd se	em.
Targeted learning outcomes	technical skills: Introduction to current advanced research topics in algorithmic re- search <u>soft skills</u> : Presentation of own and others' solutions and methods, critical dis- cussion of applied methods, techniques and solutions					
Contents	The topic will be announced before the start of the resp. semester.					
Prerequisites	None					
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercises (Individual solving of small groups, preser cussion in tutorials)	problems in tation and dis-	60 30	2 1	30 T/30 S 15 T/45 S	2 2
Exam achievements		Exar	n(s)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	Depending on the vant research liter	topics varying fro rature will be a	om sen nnounc	nester to ed befo	semester, t re the start	he rele- of the

Module name: Seminar Geome	tric Distance Pro	blems			universitä	bonn	
Module No. MA-INF 1304	Workload 120 h	Credit points 4		Frequency Every yea	/ ar		
Module coordinator	Prof. Dr. Rolf Klei	n					
Lecturer(s)	Prof. Dr. Rolf Klei	n					
Classification	Programme Cor		Compul tio	sory/ Op- onal	Semes	ter	
	M.Sc. Computer S	Science	Optiona	al	3 rd sem.		
Targeted learning outcomes	Presentation of o cussion of applied	wn and others' I methods, techi	solutior niques ai	is and me nd solutio	ethods, critio ns	al dis-	
Contents	Current topics inv reduction	Current topics involving distance problems, e.g. clustering, dimension reduction					
Prerequisites	<u>Required</u> : Discrete and Com	putational Geon	netry (M	A-INF 123)		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Seminar		10	2	30 T/90 S	4	
Exam achieve- ments		E>	kam(s)				
(graded)	Oral presentation						
Study achieve- ments (not graded)	Regular participat	ion, written rep	ort				
Forms of media							
Literature	The relevant litera ous semester	ture will be ann	ounced t	owards th	e end of the	previ-	

Module name: Seminar Chip De	sign				universitä	tbonn
Module No. MA-INF 1305	Workload 120 h	Credit points 4 Every year				
Module coordinator	Prof. Dr. Jens Vy	Prof. Dr. Jens Vygen				
Lecturer(s)	Prof. Dr. Stefan H Junior-Prof. Dr. T	lougardy, Prof. ïm Nieberg, Pr	Dr. Bern of. Dr. Je	nhard Ko ens Vyger	rte, 1	
Classification	Prograr	Programme Compu Optic		ulsory/ ional	Semes	ter
	M.Sc. Computer	Science	Optional		3 rd sem.	
outcomes	Competence to understand new theoretical results and practical so- lutions in VLSI design and related applications, as well as presenta- tion of such results <u>soft skills</u> : Ability to read and understand research papers, abstract thinking, presentation of mathematical results in a talk					
Contents	Current topics in	chip design an	d related	l applicat	ions	
Prerequisites	Required: Combinatorial Op Chip Design (MA-	otimization (MA INF 1202)	A-INF 110)2) or		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T/90 S	4
Exam achievements		E	xam(s)			
(graded)	Oral presentation	1				
Study achievements (not graded)	Regular participa	tion				
Forms of media						
Literature	The topics and th end of the previou	ie relevant liter us semester	ature wil	l be anno	ounced toward	ds the
T = Face-to-face teac	hing; S = Independe	nt study				

Module name: Seminar Combin	atorial and Geom	etric Optimizat	ion		universitä	tbonn
Module No. MA-INF 1306	Workload 120 h	Credit points 4	Frequency Every year			
Module coordinator	Prof. Dr. Marek Ka	rpinski				
Lecturer(s)	Prof. Dr. Norbert E	Blum, Prof. Dr. N	larek K	arpinski,	Prof. Dr. Ro	lf Klein
Classification	Progran	Programme Co		pulsory/ ptional	Semes	ster
	M.Sc. Computer Se	cience	Optio	nal	3 rd sem.	
outcomes	technical skills: Presentation of selected topics in the above area <u>soft skills</u> : Ability to perform individual literature search, critical reading, under- standing, and clear didactic presentation					
Contents	Current topics in c newest research lit	combinatorial an cerature	d geon	netric opt	imization ba	ased on
Prerequisites	None		n			
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T/90 S	4
Exam achievements (graded)	Oral presentation	Exa	m(s)			
Study achievements (not graded)	Regular participation, written report					
Forms of media						
Literature	The relevant literat	ure will be anno	uncedi	n time.		

Module name: Seminar Advance	ed Algorithms				universitä	tbonnl
Module No.	Workload	Credit points		Frequer	псу	
MA-INF 1307	120 h	4		Every y	rear	
Module coordinator	Prof. Dr. Marek Ka	rpinski				
Lecturer(s)	Prof. Dr. Norbert E	Blum, Prof. Dr. N	larek Kar	pinski, I	Prof. Dr. Rol	f Klein
Classification	Programme Compuls Optior		ilsory/ onal	Semes	ter	
	M.Sc. Computer Se	cience	Optiona		3 rd sem.	
outcomes	Presentation of se various application <u>soft skills</u> : Ability to perform standing, and clea	Presentation of selected advanced topics in algorithm design and various applications <u>soft skills</u> : Ability to perform individual literature search, critical reading, understanding, and clear didactic presentation				
	ture	i algoritiini desiş	sii baseu	on new	estresearci	i iitera-
Prerequisites	None		-	1 1		
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Seminar		10	2	30 T/90 S	4
Exam achievements		Exa	m(s)			
(graded)	Oral presentation					
Study achievements (not graded)	Regular participati	on, written repoi	rt			
Forms of media						
Literature	The relevant literat	ure will be anno	unced in	time.		

Module name: Lab Algorithms fo	or Chip Design				universitä	tbonn
Module No. MA-INF 1308	Workload 240 h	Credit points 8		Frequenc Every yea	y ar	
Module coordinator	Prof. Dr. Jens Vy	/gen				
Lecturer(s)	Prof. Dr. Stefan Junior-Prof. Dr.	Hougardy, Prof. Tim Nieberg, Pr	Dr. Berr of. Dr. Je	nhard Kor ens Vyger	te, N	
Classification	Progra	Programme Compul Optio		ulsory/ ional	Semest	er
	M.Sc. Computer	Science	Optiona	al	3 rd sem.	
outcomes	Competence to dling of very larg ware techniques <u>soft skills</u> : Efficient implem modelling of opt source code	Competence to implement algorithms for VLSI design, efficient han- dling of very large instances, testing, documentation. Advanced soft- ware techniques. <u>soft skills</u> : Efficient implementation of complex algorithms, abstract thinking, modelling of optimization problem in VLSI design, documentation of source code				
Contents	A currently chal precise task will	lenging probler be explained in	n will be a meetir	e chosen ng in the j	each semeste previous seme	er. The ester.
Prerequisites	<u>Required</u> : Combinatorial O 1202); Seminar Discret Algorithms (MA-	ptimization (MA e Optimization (INF 1207)	-INF 110 MA-INF	02), Chip 1205) or	Design (MA-II Lab Combina	NF torial
Format/workload/ credits	Teaching	g format	Group size	Hours/ week	Workload [h]	Credits
	Lab		8	2	30 T/210 S	8
Exam achievements		E	xam(s)			
(graded)	Oral presentatio	n				
Study achievements (not graded)	Regular participa	ation, software o	documen	itation		
Forms of media						
Literature	The topics and t end of the previo	he relevant liter ous semester	ature wil	l be anno	unced toward	s the

Module name:						A	
Lab Efficient Algo Design, Analysis	orithms for Selec and Implementa	cted Problems: tion	:		universitä	tbonn	
Module No. MA-INF 1309	Workload 240 h	Credit points 8			Frequency At least every year		
Module coordinator	Prof. Dr. Marek K	Prof. Dr. Marek Karpinski					
Lecturer(s)	Prof. Dr. Norbert	Blum, Prof. Dr.	Marek K	arpinsk	i, Prof. Dr. Ro	lf Klein	
Classification	Prograi	Programme Co		lsory/ onal	Semester		
	M.Sc. Computer Science Optional		1	2 nd and/or 3 rd sem.			
Targeted learning outcomes	Ability to design, analyze and implement efficient algorithms for se- lected computational problems.						
Contents	Design of efficien tures for selected	it exact and app I computational	proximate problem:	e algori [.] s.	thms and data	a struc-	
Prerequisites	None		•				
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lab		8	2	30 T/210 S	8	
Exam achievements		Ex	(am(s)				
(graded)	Oral presentation						
Study achievements (not graded)	Regular participa	tion, written doo	cumentat	ion			
Forms of media							
Literature	The relevant literat	ture will be annou	inced in ti	me.			
T = Face-to-face teac	hing; S = Independe	ent study					

Module name: Seminar Cryptog	Module name: Seminar Cryptography				universitätbonn		
Module No. MA-INF 1310	Workload 120 h	Credit points 4		Frequer Every y	ncy vear		
Module coordinator	Prof. Dr. Joachim von zur Gathen						
Lecturer(s)	Prof. Dr. Joachim v	on zur Gathen					
Classification	Progran	Programme Compu Opti			Semes	ster	
	M.Sc. Computer Sc	ience	Optior	nal	3 rd sem.		
outcomes	Understanding reset this into a presenta terial. Developing a nates fellow studen <u>soft skills</u> : Understanding and dia. Motivating oth research results.	Understanding research publications, often written tersely. Distilling this into a presentation. Determination of relevant vs. irrelevant ma- terial. Developing a presentation (usually in PowerPoint) that fasci- nates fellow students. <u>soft skills</u> : Understanding and presenting material both orally and in visual me- dia. Motivating other students to participate. Critical assessment of research results					
Contents	A special topic wit studied in depth, b	hin cryptograph ased on the curre	y, chan ent rese	ging fro earch lit	om year to <u>:</u> erature.	year, is	
Prerequisites	Recommended: Cryptography (MA-IN	NF 1103)					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Seminar		10	2	30 T/90 S	4	
Exam achievements		Exam	1(s)				
(graded)	Oral presentation						
Study achievements (not graded)	Regular participatio	on, written report	t				
Forms of media							
Literature	Current conference	publications, to	be ann	ounced	in time		

Master

Module Handbook

Master Programme "Computer Science"

Area of Competence

Graphics, Vision, Audio

MA-INF 2101	L4E2	8 CP	Foundations of Graphics, Vision, and Audio	ReK
MA-INF 2201	L4E2	8 CP	Computer Vision	DC
MA-INF 2202	L4E2	8 CP	Computer Animation	AW
MA-INF 2203	L4E2	8 CP	Selected Topics in Signal Processing	MC
MA-INF 2204	L2E1	4 CP	Rendering: Global Illumination and Real-Time	ReK
			Photorealism	
MA-INF 2205	L2E1	4 CP	Digital Geometric Models: Representation,	ReK
			Creation and Editing	
MA-INF 2206	Sem	4 CP	Seminar Graphics, Vision, Audio	ReK
MA-INF 2301	L2E1	4 CP	Advanced Topics in Computer Vision	DC
MA-INF 2302	L4E2	8 CP	Physics-based Modelling	AW
MA-INF 2303	L4E2	8 CP	Selected Topics in Multimedia Retrieval	MC
MA-INF 2304	L2E1	4 CP	Rendering Techniques II	ReK
MA-INF 2305	L2E1	4 CP	Geometry Processing II	ReK
MA-INF 2306	L2E1	4 CP	Virtual Reality	ReK
MA-INF 2307	Lab	8 CP	Lab Graphics, Vision, and Audio	ReK

(L: Lecture, E: Exercise, Sem: Seminar)

Module coordinators:

Michael Clausen (MC), Daniel Cremers (DC), Reinhard Klein (ReK), Andreas Weber (AW),

Module name:							
Foundations of G	raphics, Vision, a	nd Audio			universitä	tbonn	
Module No. MA-INF 2101	Workload 240 h	Credit points		Frequency Every year			
Module	Prof. Dr. Reinhard	Klein					
coordinator							
Lecturer(s)	Prof. Dr. Michael (Prof. Dr. Reinhard	Clausen, Prof. Dr Klein Prof Dr /	. Danie Andreas	Cremers Weber	,		
	Program	Programme Compulsory/ Se					
Classification	MOOLO		Op	tional	1 st		
Targeted learning	M.Sc. Computer Se	cience	Optior	lal	1 st sem.		
outcomes	Knowledge of basic Vision and Audio wi problems in these fit soft skills: Research abilities, i	mathematical teo th a strong emph elds nformation retriev	chniques asis on al abilit	common their appl ies, collab	ly used in G ication to rea oration abilit	raphics, al world ies, self	
Contents	 Fourier and wavely and filtering Affine and projecti (rigid body motion) 	et transforms with ve transformation cinematic chains	n applic s with a	ations to a	audio signal s to image fo	analysis rmation	
Droroquisitos	 Parametric curves Elements of continto mesh processing Ordinary differentialing Variational method image processing Monte Carlo method This lecture has bee of Graphics, Vision, in the second seco	 Parametric curves and surfaces with applications to 3D modelling Elements of continuous and discrete differential geometry with application to mesh processing Ordinary differential equations with applications to physical based modelling Variational methods and partial differential equations with applications to image processing Monte Carlo methods with applications to photorealistic rendering This lecture has been designed as a team-taught cycle of lectures in the field of Craphica Vision, and Audia 					
Prerequisites	Recommended: Mathematical backg numerical methods)	round (multidimer	nsional a	inalysis ar	id linear algel	bra,	
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture		60	4	60 T/90 S	5	
Exam achievements	Exercise	Exa	 m(s)	2	30 1/60 3	3	
(graded)	Written exam						
Study achievements (not graded)	Successful exercis	e participation					
Forms of media							
Literature	 P. Shirley et al.: F ters, 2005 J. G. Proakis, D. (1996 J. Bigun: Vision w L. Szirmay-Kalos: Computer Graphic URL: citeseer ist 	Fundamentals of C G Manolakis: Digita vith Direction, Spri Monte-Carlo-Meth cs, Vienna Univers	ompute al Signa nger, 20 nods in (sity of Te	r Graphics Processin 006 Global Illur echnology,	, 2 nd edition, ng, Prentice F mination, Inst Vienna.	A K Pe- Iall, titute of	

Module name: Computer Vision					universitä	it bonn
Module No. MA-INF 2201	Workload 240 h	WorkloadCredit pointsFrequency240 h8Every year				
Module coordinator	Prof. Dr. Daniel Cre	emers				
Lecturer(s)	Prof. Dr. Daniel Cre	emers				
Classification	Program	nme	Comp Opt	ulsory/ ional	Semes	ster
	M.Sc. Computer Sc	cience	Optior	nal	2 nd sem.	
outcomes	technical skills: Students will learr applications to con <u>soft skills</u> : Productive work in vidual approaches methods, discussio	n about various nputer vision prol small teams, de and solutions, on in groups.	mather blems evelopm critica	natical r ent and al reflec ⁻	nethods ar realization tion of cor	nd their of indi- npeting
Contents	The class will cover applications in com- partial differential timation, factorization ple views, and lever tracking.	er a number of nputer vision, in p equations for im tion techniques f I set and graph o	mather particul age enl for 3D cut met	natical r ar variat nanceme reconstr hods for	nethods ar ional metho ent and mo uction from segmentat	nd their ods and tion es- n multi- ion and
Prerequisites	Required: Foundations of Gra <u>Recommended</u> : Mathematical back gebra)	phics, Vision, an ground (multidin	d Audio nension	(MA-INF al analys	⁻ 2101) sis and line	ar al-
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercises		60 30	42	60 T/90 S 30 T/60 S	5 3
Exam achievements	-	Exam	า(ร)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 Y.Ma, S. Soatto, J O. Faugeras, Q. Lu Images R. Hartley, A. Ziss S. Osher, R. Fedki 	. Kosecka, S. Sastr Jong, T Papadopou erman: Multiple Vi w: Level Set Metho	ry: An In ulou: The ew Geor ods and	vitation to e Geomet netry in C Dynamic	o 3·D Vision ry of Multiple Computer Vis Implicit Surf	e sion faces

Module name: Computer Anima	tion				universitä	tbonn
Module No. MA-INF 2202	Workload 240 h	WorkloadCredit pointsFrequency240 h8Every year				
Module coordinator	Prof. Dr. Andreas	Weber				
Lecturer(s)	Prof. Dr. Andreas	Weber				
Classification	Progran	nme	Comp Opt	ulsory/ ional	Semest	er
	M.Sc. Computer So	cience	Optio	nal	2 nd sem.	
outcomes	technical skills: Students will learn tion. They will lear up with algorithmi of virtual character <u>soft skills</u> : Social competence and oral presentat	n fundamental pa rn to use mather c solutions of pr rs. es (work in grou ion)	aradign matical roblems ups), co	ns used models of the	in computer of motions t synthesis of r cative skills (anima- o come notions (written
Contents	Fundamentals of c motions; motion c styles; morphing hierarchy	Fundamentals of computer animation; kinematics; representations of motions; motion capturing; motion editing; motion textures; motion styles; morphing techniques; facial animations; cognitive modelling hierarchy				
Frerequisites	Foundations of Gra	aphics, Vision, ar	nd Audi	o (MA-II	NF 2101)	
Format/workload/ credits	Teaching	format	Group size	Hours	Workload [h]	Credits
	Lecture Exercise (Discussions of theo in groups; realization ware projects in sma	retical concepts ns of small soft- all groups.)	60 30	4 2	60 T/90 S 30 T/60 S	5 3
Exam achievements		Exa	m(s)			
(graded) Study achievements (not graded)	Oral exam Successful exercise	e participation				
Forms of media						
Literature	 Dietmar Jackel, S Computeranimati Rick Parent: Com Morgan Kaufman Frederic I. Parke A K Peters, Ltd. 1 	tephan Neunreith on, Springer 2006 puter Animation: / Publishers 2002 , Keith Waters: Co 996	er, Friec Algorith mputer	rich Wag ms and T Facial Ar	gner: Methoden echniques, nimation.	der

Module name: Selected Topics	in Signal Process	ing			universitä	tbonn
Module No. MA-INF 2203	Workload 240 h	Credit points 8		Frequency Every yea	/ ar	
Module coordinator	Prof. Dr. Michael C	Clausen				
Lecturer(s)	Prof. Dr. Michael C	Clausen				
Classification	Progran	Programme Compulsory/ Optional				
	M.Sc. Computer So	cience	Optio	nal	2 nd sem.	
outcomes	Learning advanced a signal processing. Si essing with a focus of and designing audio cal modelling of sign and implementation those problems. Effic soft skills: Capability to analyz own solutions and so	<u>echnical skills</u> : earning advanced as well as state of the art topics and techniques in digital ignal processing. Study examples from the field of digital audio signal proc- ssing with a focus on music audio. Develop skills for analysing audio signals and designing audio features for selected application scenarios. Mathemati- al modelling of signal processing problems in practical applications. Design and implementation of corresponding algorithms and data structures solving hose problems. Efficiency issues. <u>soft skills</u> : Capability to analyze. Time management. Strength of purpose. Discussing				
Contents	Advanced technique tures describing me concepts for conte signal processing analysis, signal con	Advanced techniques for filter design, design and extraction of fea- tures describing multimedia signals, efficient DSP algorithms, general concepts for content-based analysis of multimedia signals. Selected signal processing applications, for example content-based music analysis, signal compression, denoising, source separation.				
Format/workload/			Group	Hours/		
credits	Lecture Exercise (Theoretical consolic presented. Practical basic algorithms, pa groups supported by multimedia lab)	lation of methods realisation of rtially in small tutors in our	size 60 30	week 4 2	60 T/90 S 30 T/60 S	5 3
(graded)	Oral exam	EXa	m(s)			
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 Lecture script and Hayes: Statistical 1996 Proakis, Manolaki Klapuri, Davy: S Springer, 2006 	d selected researc Digital Signal Pro is: Digital Signal P Signal Processing	h public cessing rocessin g, Meth	ations and Mode ng, Prentic ods for I	lling, John W e Hall, 1996 Ausic Transo	iley, cription,

Module name: Rendering: Glob Photorealism	al Illumination an	d Real-Time			universitä	tbonn
Module No. MA-INF 2204	Workload 120 h	Credit points 4		Frequency Every vear		
Module	Prof. Dr. Reinhard K	lein				
	Prof Dr Poinbard K	loin				
Classification	Program	nme	Comp Opt	ulsory/ onal	Semest	er
	M.Sc. Computer Sci	ence	Option	al	2 nd sem.	
l argeted learning outcomes	technical skills: Analytical formulatic of techniques and al Knowledge of the ma 3D-scences and vol basic algorithms. <u>soft skills</u> : Analytical problem of cal problems in the implementations, se self-management	<u>schnical skills</u> : nalytical formulation of problems related to image synthesis and knowledge f techniques and algorithms for the generation of photorealistic image data. nowledge of the major algorithms for the simulation of light distributions in D-scences and volume data sets. Self-dependent implementation of the asic algorithms. <u>oft skills</u> : nalytical problem description, creativity, self-dependent solution of practi- al problems in the area of rendering, presentation of solution strategies and mplementations, self-dependent literature research, collaboration abilities,				
Contents	Topics among other properties and light equation; algorithms tion and rendering generation in real-tin state of the art resea	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	Required: Foundations of Grap <u>Recommended</u> : Algorithms and data sis und linear algeb merical analysis and	hics, Vision, and A structures, basic ra, basic knowle	Audio (M knowled dge in s algebra	A-INF 21 Ige on m tochasti C++	.01) nultidimensiona cs and statisti	al analy. cs, nu·
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Lecture Exercise		60 30	2	30 T/30 S 15 T/45 S	2 2
Exam achievements		Exa	m(s)			
(graded)	Oral exam (This 4LP-module can Representation, Creati ics I" with one exam or mester.)	be combined with th on and Editing" to a nly, provided that bo	ne 4LP-m 8LP-mo oth modul	odule "Di dule "Adv es are do	gital Geometric anced Compute ne within the sa	Models: r Graph- me se-
Study achievements (not graded)	Successful exercise	participation				
Literature	 L. Szirmay-Kalos: puter Graphics, Vi URL: citeseer.ist.p P. Dutre, K. Bala, M. Pharr, G. Hum J. Kautz, J. Lehtir Practice, Siggraph 	 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, 2004 J. Kautz, J. Lehtinen, PP. Sloan: Precomputed Radiance Transfer: Theory and Device Computer Science Computer Scie				

 $T = Face \cdot to \cdot face teaching; S = Independent study$

Module name: Digital Geometri and Editing	c Models: Repres	entation, Creat	ion		universitä	tbonn.
Module No.	Workload	Credit points		Frequency	/	
MA-INF 2205	120 h	4		Every yea	ar	
Module coordinator	Prof. Dr. Reinhard	Klein				
Lecturer(s)	Prof. Dr. Reinhard	Klein	1			
Classification	Prograr	nme	Com Op	pulsory/ otional	lsory/ Semester onal	
	M.Sc. Computer S	cience	Option	nal	2 nd sem.	
outcomes	technical skills: Analytical formulati knowledge of techni ometry data. Espec three-dimensional d geometry processing <u>soft skills</u> : Analytical problem of cal problems in the gies and implement abilities, self-manag	<u>echnical skills</u> : Inalytical formulation of problems related to geometry processing and nowledge of techniques and algorithms to optimize, process and store ge- metry data. Especially, learning of techniques to generate highly detailed hree-dimensional digital models of real objects and to implement current geometry processing algorithms. <u>oft skills</u> : Inalytical problem description, creativity, self-dependent solution of practi- ral problems in the area of mesh processing, presentation of solution strate- ties and implementations, self-dependent literature research, collaboration				
Contents	Topics among other (Laser scanning, re Point based represe structures and mes Mesh decimation a fine und fine-to-coar state of the art resea	will be: Methods gistration and in ntations, Reconstr h compression, O nd refinement, H se, Editing of poly arch will be preser	for the g tegration ruction t ptimizat ierarchin gonal m ited.	generation n of single echniques ion: denoi cal repres neshes. In	of polygonal e mesh part , Efficient me sing and sm entations: co addition resu	meshes s, etc.), esh data oothing, parse-to- lts from
Prerequisites	Required: Foundations of Grap <u>Recommended</u> : Algorithms and dat geometry, knowledg well as numerical ar	hics, Vision, and A a structures or ki ge on multidimen alysis and numeri	Audio (N nowledg sional a cal linea	A-INF 21C e of basic malysis un ar algebra.	1) discrete dif nd linear alg C++	ferential ebra as
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercise		60 30	2 1	30 T/30 S 15 T/45 S	2 2
Exam achievements		Exa	m(s)			
(graded)	Oral exam (This 4LP-module can a 8LP-module "Advan both modules are done	be combined with th ced Computer Grapl within the same se	ne 4LP-m hics I" wi mester.)	odule "Ren th one exan	dering Techniq n only, provide	ues I" to d that
Study achievements (not graded)	Successful exercis	e participation				
Literature	 R. Scopigno, C. A rographics Tutori E. Grinspun, M. I Applied Introduct M. Botsch, M. Pa graph Course Not 	Andujar, M. Goese al, 2002 Desbrun (organize ion, Siggraph Cou uly: Geometric Mo es, 2006	le, H. Le ers): Dise rse Note odeling l	ensch: 3D crete Diffe es, 2006 Based on	Data Acquist rential Geom Friangle Mest	ion, Eu- etry: An nes, Sig-

Module name: Seminar Graphic	s, Vision, Audio				universitä	tbonn
Module No. MA-INF 2206	Workload 120 h	WorkloadCredit pointsFrequency120 h4Every semester				
Module coordinator	Prof. Dr. Reinhard	Klein				
Lecturer(s)	Prof. Dr. Michael C Prof. Dr. Reinhard	Clausen, Prof. Dr Klein, Prof. Dr. /	. Danie Andreas	l Cremers Weber	5,	
Classification	Program	nme	Com Op	pulsory/ tional	Semes	ster
	M.Sc. Computer So	cience	Optior	nal	2 nd and 3 rd	^d sem.
outcomes	technical skills: Ability to read, ur research in Graphi <u>soft skills</u> : Ability to perform son of algorithms research level.	technical skills: Ability to read, understand and present selected topics on current research in Graphics, Vision and Audio. <u>soft skills</u> : Ability to perform literature research, critical evaluation and compari- son of algorithms and methods, structured presentation of results at				
Contents	Current topics in G	araphics, Vision,	and Au	dio.		
Prerequisites	Recommended: Mathematical back gebra, basic nume Foundations of Gra strongly recommen	ground (multidi rical methods) aphics, Vision, ar nded.	mensio nd Audi	nal analy o (MA-IN	sis and linea F 2101) are	r al-
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T/90 S	4
Exam achievements		Exa	m(s)			
(graded)	Oral presentation					
Study achievements (not graded)	Regular participation, written report					
Forms of media						
Literature	Selected articles o	n latest topics o	f Comp	uter Grap	hics	
T = Face-to-face tead	ching; S = Independer	nt study				

Module name: Advanced Topics	in Computer Visi	on			universitä	tbonn
Module No. MA-INF 2301	Workload 120 h	Vorkload Credit points Frequency L20 h 4 Every year				
Module coordinator	Prof. Dr. Daniel Cr	emers				
Lecturer(s)	Prof. Dr. Daniel Cr	emers				
Classification	Progran	nme	Comp Opt	ulsory/ ional	Semest	er
	M.Sc. Computer Se	cience	Option	nal	3 rd sem.	
Targeted learning outcomes	technical skills: Advanced compute soft skills: Productive work in vidual approaches methods, discussio	er vision method small teams, d and solutions, on in groups.	s levelopr critic	nent an cal refle	d realization ection of con	of indi- npeting
Contents	The class focuses and image proces with recent develop	on advanced top sing. In particu oments in compl	bics in t lar, it uter vis	he field will mal	s of compute ke students f arch.	r vision amiliar
Prerequisites	<u>Required</u> : Foundations of Gra <u>Recommended</u> : Computer Vision (I	aphics, Vision, ar MA-INF 2201)	nd Audi	o (MA-II	NF 2101)	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Lecture Exercises		60 30	2 1	30 T/30 S 30 T/30 S	2 2
Exam achievements		Exa	m(s)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise participation					
Forms of media						
Literature	Latest topic-related in advance of the l	d research articl ecture.	es and	literatur	e will be ann	ounced

Module name: Physics-based M	lodelling				universitä	tbonn
Module No. MA-INF 2302	Workload 240 h	Credit points 8		Frequency Every yea	y ar	
Module coordinator	Prof. Dr. Andreas \	Weber				
Lecturer(s)	Prof. Dr. Andreas \	Weber				
Classification	Progran	nme	Com Op	pulsory/ otional	Semes	ster
	M.Sc. Computer So	cience	Optio	nal	3 rd sem.	
Targeted learning outcomes	technical skills: Students learn the ling for computer shall be able to c the algorithmic tec to come up with so <u>soft skills</u> : Social competence and oral presentat	<u>achnical skills</u> : tudents learn the fundamental techniques of physics-based model- ng for computer graphics and computer animation. The students hall be able to choose appropriate mathematical models. Knowing he algorithmic techniques and algorithmic issues, they shall be able o come up with software solutions for specific problems. <u>oft skills</u> : Social competences (work in groups), communicative skills (written				
Contents	Particle simulation tion; collisions res tion; physics-based	n; rigid bodies; r ponse; cloth mod d motion editing	nulti-bo delling;	ody-syster hair moo	ms; collision lelling; fluid	detec- anima-
Prerequisites	Required: Foundations of Gra	aphics. Vision, a	nd Audi	o (MA-INI	F 2101)	
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercises (Discussions of theo in groups; realization ware projects in sma	Lecture60460 T/90 SExercises30230 T/60 S(Discussions of theoretical concepts in groups; realizations of small soft- ware projects in small groups)0				
Exam achievements		Exa	m(s)			
(graded)	Oral exam					
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 Dietmar Jackel, Scomputeranimati David M. Bourg: F Advanced course 	Stephan Neunreit on, Springer 2006 Physics for Game I notes on physics	her, Fri Develop based r	edrich Wa ers, O'Reil nodelling	ngner: Metho Iy	den der

 $T = Face \cdot to \cdot face teaching; S = Independent study$

Module name: Selected Topics in Multimedia Retrieval					universitä	tbonn
Module No. MA-INF 2303	Workload 240 h	Credit points 8		Frequency Every yea	y ar	
Module coordinator	Prof. Dr. Michael C	Clausen				
Lecturer(s)	Prof. Dr. Michael C	Clausen				
Classification	Program	nme	Com Op	pulsory/ otional	Semes	ster
	M.Sc. Computer Se	cience	Optio	nal	1 st or 3 rd s	sem.
outcomes	Learning advanced based search in m 3D data, etc). Deve indexing technique signal processing plementation of co those problems. Et <u>soft skills</u> : Capability to analy cussing own solution	<u>eernical skills</u> : Learning advanced topics as well as efficient algorithms for content- based search in multimedia documents (audio, motion capture data, 3D data, etc). Develop skills in designing suitable data structures and ndexing techniques for efficient retrieval. Mathematical modelling of signal processing problems in practical applications. Design and im- plementation of corresponding algorithms and data structures solving shose problems. Efficiency issues. <u>soft skills</u> : Capability to analyze. Time management. Strength of purpose. Dis-				
Contents	Group theoretic c techniques for de niques for hierarc models. Similarity domains. Statistica	Group theoretic concepts for multimedia retrieval, robust retrieval techniques for deformations, concepts from invariant theory. Tech- niques for hierarchical indexing. Advanced problem-specific retrieval models. Similarity measures for selected problems and application domains. Statistical concepts for modelling data variability				
Prerequisites	None					
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture60460 T/90 SExercises30230 T/60 S(Theoretical consolidation of methods presented. Practical realisaton of ba- sic algorithms, partially in small groups supported by tutors in our multimedia lab)60460 T/90 S					53
Exam achievements		Exa	m(s)			
(graded)	Ural exam					
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 Meinard Müller trieval. Springe Lecture script a 	: Methods for R r 2007 and selected rese	earch a	and Effici rticles	ent Multime	dia Re-

Module name:	rials and Images				univorcitä	Å
Rendering. Mater	riais and images	1			universita	LDONN
Module No.	Workload	Credit points		Frequency		
MA-INF 2304	120 h	4		Every yea	ar	
Module coordinator	Prof. Dr. Reinhard	Klein				
Lecturer(s)	Prof. Dr. Reinhard	Klein				
Classification	Prograr	nme	Com Op	oulsory/ tional	Semes	ster
	M.Sc. Computer Sci	ence	Option	al	1 st or 3 rd se	em.
	technical skills: Analytical formulation knowledge of advant methods and model optical material pro- of methods and mo- rendering technique tion of the basic algors <u>soft skills</u> : Analytical problem of cal problems in the presentation of solute erature research, co-	<u>echnical skills</u> : Analytical formulation of problems related to image based rendering an knowledge of advanced techniques in the field of rendering. Knowledge of methods and models for the acquisition and description of light sources an optical material properties for Computer Graphics applications. Knowledge of methods and models for the acquisition and description of image base rendering techniques and digital photography. Self-dependent implementation ion of the basic algorithms. <u>soft skills</u> : Analytical problem description, creativity, self-dependent solution of practical problems in the area of image based rendering and digital photography presentation of solution strategies and implementations, self-dependent lip erature research, collaboration abilities, self-management				ing and ledge of owledge e based ementa- f practi- ography, dent lit-
Contents	topics among others techniques; algorithi photography for ima photography	s will be: advanced ms and techniques ge based scene m	of imaged of imaged of imaged of imaged of imaged of imaged of the second of the secon	al acquisit ge based r and rende	endering; dig ering; compu	ital tational
Prerequisites	Required: Foundations of Grap <u>Recommended</u> : Algorithms and data sis und linear algebr merical analysis and	hics, Vision, and A structures, basic a, basic knowledg numerical linear	Audio (M knowlec ge in sto algebra.	A-INF 210 Ige on mul chastic an C++	1) Itidimensiona d statistics,	l analy- nu-
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture		60	2	30 T/30 S	2
	Exercises		30	1	15 T/45 S	2
Exam achievements	0	Exa	m(s)			
(graded)	Oral exam (This 4LP-Modul can b 8LP-Modul "Shape Ar exam only, provided th	e combined with the nalysis: Classificati nat both modules are	e 4LP-Mo ion, Mat e done wi	dul "Geome ching and thin the sar	etry Processing Retrieval" wit me semester.)	g II" to a h one
(not graded)	Successful exercis	e participation				
Forms of media						
Literature	 H.P.A. Lensch, M Graphics, Siggrap P. Debevec, E. Re ory and Applicatio N. Hoffman (org graph Course Not R. Raskar, J. Turn Course Notes, 20 	I. Goesele (organi oh Course Notes, 2 einhard (organizer ons, Siggraph Cou anizer): Physically es, 2006 nblin (organizers): 06	zers): R 2005 rs): High rse Note y Basec Compu	ealistic M -Dynamic- es, 2006 Reflectar tational Pf	aterials in Co Range Imagii nce for Gam notography, S	omputer ng: The- es, Sig- Siggraph
Module name: Shape Analysis: Classification, Matching and Retrieval				universitätbonn		
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Module No. MA-INF 2305	Workload 120 h	Credit points 4		Frequency Every year		
Module coordinator	Prof. Dr. Reinhard Klein					
Lecturer(s)	Prof. Dr. Reinhard	Klein				
Classification	Programme Compulsory/ Op- Se tional				Semes	ster
	M.Sc. Computer S	cience	Optiona		1 st or 3 rd s	sem.
Targeted learning outcomes	technical skills: Analytical formulati analysis and shape and techniques from rithms. <u>soft skills</u> : Analytical problem cal problems in the presentation of solu erature research, co	technical skills: Analytical formulation of problems related to geometry processing, shape analysis and shape retrieval as well as knowledge of advanced algorithms and techniques from these fields. Self-dependent implementation of the algo- rithms. <u>soft skills</u> : Analytical problem description, creativity, self-dependent solution of practi- cal problems in the area of image based rendering and digital photography, presentation of solution strategies and implementations, self-dependent lit-				
Contents	 This class is focussed on advanced topics in the field of geometry processing. Students will get familiar with recent developments in the area of shape analysis and shape retrieval. 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 					
Prerequisites	Required: Foundations of Graphics, Vision, and Audio (MA-INF 2101) Recommended: Algorithms and data structures, basic knowledge on multidimensional analy- sis und linear algebra, basic knowledge in stochastic and statistics, numeri-					
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lecture Exercises		60 30	2 1	30 T/30 S 15 T/45 S	2 2
Exam achievements (graded)	Oral exam (This 4LP-module can Images" to a 8LP-mo provided that both mo	Ex be combined with t dule "Advanced Cor odules are done with	am(s) the 4LP-mo nputer Gra tin the sam	dule "Rende phics II" wit e semester.	ering: Material h one exam or	ls and nly,
Study achievments (not graded)	Successful exercis	e participation				
Forms of media Literature	 T. Funkhouser, M. Kazhdan, Shape-Based Retrieval and Analysis of 3D-Models, Siggraph Course Notes, 2004 L. Dryden, K.V. Mardia, Statistical Shape Analysis, John Wiley & Sons, 1998 H. Krim, Jr, A. Yezzi (editors): Statistics and Analysis of Shapes (Modeling an Simulation in Science, Engineering and Technology), Birkhäuser Boston, 2006 					

Module name: Virtual Reality					universitä	tbonn	
Module No. MA-INF 2306	Workload 120 h	Credit points 4		Frequer Every y	Frequency Every year		
Module coordinator	Prof. Dr. Reinhard	Klein					
Lecturer(s)	Prof. Dr. Reinhard	Klein					
Classification	Progran	nme	Compu Optio	lsory/ onal	Semes	ster	
	M.Sc. Computer Se	cience	Optiona		3 rd sem.		
outcomes	Basic knowledge of Systems, Broad kn time rendering alg and sound, knowle effect generation, a <u>soft skills</u> : Analytical problems tion strategies an search, collaborati	Basic knowledge of hard- and software components of current VR- Systems, Broad knowledge of tracking-, collision detection- and real- time rendering algorithms, knowledge of methods to integrate haptic and sound, knowledge of GPU programming with emphasis on special effect generation, ability to implement components of a VR-System <u>soft skills</u> : Analytical problem description, creativity, self-dependent solution of practical problems in the area of Virtual Reality, presentation of solu- tion strategies and implementations, self-dependent literature re- search, collaboration abilities, self management					
Contents	Scene Graphs, Stereo Seeing (HW, SW), Tracking (HW, SW), Accelera- tion Techniques (LOD; Culling), Collision detection, Haptics, Sound, Special effects (GPU-Programming)						
Prerequisites	<u>Recommended</u> : Mathematical back gebra, foundations foundations of com	ground (multidi of numerical m	mensiona ethods), g	al analys good kn	sis and linea owledge of t	ir al- the	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises		60 30	2 1	30 T/30 S 15 T/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media							
Literature	 K. Stanney (ed.): Handbook of Virtual Environments. Lawrence Erlbaum Associates, 2002 W. Sherman, A. Craig: Understanding Virtual Reality. Morgan Kaufman, 2002 D. Pape: Commodity-Based Projection VR, Siggraph Course Notes, 2006 N. Tatarchuk (organizer): Advanced Real-Time Rendering in §D Graphics and Games, Siggraph Course Notes, 2006 						

Module name: Lab Graphics, Vi	Module name: _ab Graphics, Vision, and Audio				universitä	tbonn
Module No. MA-INF 2307	Workload 240 h	Credit points 8		Frequenc Every ye	y ar	
Module coordinator	Prof. Dr. Reinhard	Klein				
Lecturer(s)	Prof. Dr. Michael (Prof. Dr. Reinhard	Clausen, Prof. D Klein, Prof. Dr.	r. Dani Andrea	el Creme as Weber	rs,	
Classification	Programme Comp Opt			pulsory/ ptional	Semest	er
	M.Sc. Computer Science Optic			nal	3 rd sem.	
Targeted learning outcomes	technical skills: Ability to design, lected problems ir <u>soft skills</u> : Research abilities documentation an	technical skills: Ability to design, analyze and implement efficient algorithms for se- lected problems in Graphics, Vision and Audio. <u>soft skills</u> : Research abilities, creativity, ability for individual implementation, documentation and presentation of research results.				
Contents	Selected algorithn	ns and technique	es from	n Graphic	s, Vision and <i>i</i>	Audio
Prerequisites	Recommended: Mathematical bac bra, basic numeric Foundations of (strongly recomme	kground (multic cal methods) Graphics, Vision nded	limensi n, and	ional ana Audio	lysis and linea (MA-INF 210	ar alge- 01) are
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Lab		8	4	60 T/180 S	8
Exam achievements		Ex	am(s)			
(graded)	Oral presentation					
Study achieve- ments (not graded)	Regular participation, written documentation					
Forms of media						
Literature	Selected articles of	on latest topics o	of Com	puter Gra	phics	

Master

Module Handbook

Master Programme "Computer Science"

Area of Competence

Information and Communication Management

MA-INF 3101	L4E2	8 CP	High Performance Networking	РМ
MA-INF 3102	L4E2	8 CP	Information Systems Engineering	ABC
MA-INF 3201	L2E1	4 CP	Network Security	РМ
MA-INF 3202	L2E1	4 CP	Mobile Communication	РМ
MA-INF 3203	L4E2	8 CP	Intelligent Information Systems	RM
MA-INF 3204	L2E1	4 CP	Distributed and Mobile Information Systems	TB
MA-INF 3205	L2E1	4 CP	Internet Information Systems	SLK
MA-INF 3206	L2E1	4 CP	Aspect-oriented Software Development	GK
MA-INF 3207	L2E1	4 CP	Advanced Logic Programming	ABC
MA-INF 3208	L2E1	4 CP	Model-Driven Engineering	ABC
MA-INF 3209	Sem	4 CP	Seminar Selected Topics in Communication	РМ
			Management	
MA-INF 3210	Sem	4 CP	Seminar Advanced Topics in Information Man-	ABC
			agement	
MA-INF 3211	Sem	4 CP	Seminar Selected Topics in Sensor Networks	PJM
			Research	
MA-INF 3301	L2E1	4 CP	Spatial Information Systems	VS
MA-INF 3302	L2E1	4 CP	Database Techniques for Event Monitoring	RM
			Systems	
MA-INF 3303	Sem	4 CP	Seminar Enterprise Software Engineering	ABC
MA-INF 3304	Lab	8 CP	Lab Communication and Communicating De-	РМ
			vices	
MA-INF 3305	Lab	8 CP	Lab Information Systems	ABC
MA-INF 3306	Lab	8 CP	Lab Enterprise Software Engineering	ABC
MA-INF 3307	L2E1	4 CP	Lecture Sensor Networks	PJM
MA-INF 3308	Sem	4 CP	Seminar Selected Topics in Ubiquitous	PJM
			Computing	

(L: Lecture, E: Exercise, Sem: Seminar)

Module coordinators:

Armin B. Cremers (ABC), Rainer Manthey (RM), Pedro José Marrón (PJM), Peter Martini (PM), Thomas Bode (TB), Günter Kniesel (GK), Stefan Lüttringhaus-Kappel (SLK), Volker Steinhage (VS)

Module name: High Performance Networking				universitätbonn			
Module No. MA-INF 3101	Workload 240 h	Credit points 8		Frequency Every year			
Module coordinator	Prof. Dr. Peter Martini						
Lecturer(s)	Prof. Dr. Peter Mai	rtini, Prof. Dr. Pe	edro Jo	sé Marrór	1		
Classification	Programme Comp Op			pulsory/ ptional	Semes	ster	
	M.Sc. Computer So	cience	Option	nal	1 st or 3 rd s	sem.	
l argeted learning outcomes	The students come to know fundamental concepts of modeling, evaluation and efficiency optimization of communication systems and communicating devices. They reach the ability to work on real-life issues in the areas of dynamic behavior of networks and intercon- nected devices with measurements, simulation and/or mathematical analysis. <u>soft skills</u> : Theoretical exercises to support in-depth understanding of lecture topics and to stimulate discussions, practical exercises in teamwork to support time management, targeted organisation of practical work and critical discussion of own and others' results						
Contents	Networking fundamentals, performance measurements in TCP/IP based networks, modeling of networks and networked devices, TCP/IP performance over wireless and/or mobile networks, traffic engineering, performance management, active queue management, Ouality of Service						
Prerequisites	<u>Recommended</u> : Bachelor-level kno nology	wledge of Data	Commi	unication	and Interne	t Tech-	
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises (Practical exercises) art network simulation	with state-of-the- on software)	60 30	4 2	60 T/60 S 30 P/90 S	4 4	
Exam achievements (graded)	Written exam	Exa	m(s)				
Study achievements (not graded)	Successful exercise	e participation					
Forms of media Literature	 M.Hassan, R.Jain, "High Performance TCP/IP Networking", Pearson Prentice Hall 2004; M.C. Calzarossa, S. Tucci, "Performance Evaluation of Complex Systems: Techniques and Tools", Springer 2002; R. Jain, "The Art of Computer Systems Performance Analysis", Wiley 1991 						

Module name: Information Syst	ems Engineering				universitä	tbonn		
Module No. MA-INF 3102	Workload 240 h	Credit points 8		Frequency Every yea	y ar			
Module coordinator	Prof. Dr. Armin B.	Cremers						
Lecturer(s)	Prof. Dr. Armin B.	Cremers, Prof. [Dr. Rain	er Manth	еу			
Classification	Progran	Programme Com Op			Semes	Semester		
	M.Sc. Computer So	cience	Option	nal	1 st or 3 rd s	em.		
outcomes	technical skills: Understanding the ing and engineerin of very large data to soft skills: Communicative sk tions), self-compet ity), social skills teams)	Understanding the most important paradigms and methods of model- ing and engineering large-scale software including advanced aspects of very large data bases and distributed information systems. <u>soft skills</u> : Communicative skills (oral/written presentation, "defending" solu- tions), self-competence (time management, self-organisation, creativ- ity), social skills (constructive discussion, sharing work in small						
Contents	Software Architecture, patterns and styles, elements of service- oriented architecture; advanced aspects of object-oriented modeling, abstract data types, polymorphism, behavioral refinement; object- oriented application frameworks, business process redesign, web ap- plications; architectural layers of database servers; transactional in- formation systems							
Prerequisites	None							
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits		
	Lecture Exercises		60 30	4 2	60 T/60 S 30 P/90 S	5 3		
Exam achievements		Exa	m(s)					
(graded)	Written exam							
Study achievements (not graded)	Successful exercise	e participation						
Forms of media								
Literature	 Eliens: Object-orie Addison Wesley, 2 additional papers 	ented Software De 2000	velopme	ent, 2 nd ed	ition,			

Module name: Network Security	Nodule name: Network Security				universitä	tbonn	
Module No. MA-INF 3201	Workload 120 h	Credit points 4		Frequency Every year			
Module coordinator	Prof. Dr. Peter Mai	Prof. Dr. Peter Martini					
Lecturer(s)	Prof. Dr. Peter Mai	rtini					
Classification	Programme Com			pulsory/ otional	Semes	ster	
	M.Sc. Computer So	cience	Optior	nal	2 nd sem.		
l argeted learning outcomes	technical skills: The students learn includes risks and cepts to increase t oriented introducti their weaknesses. <u>soft skills</u> : Theoretical exercise topics and to stime to support time m and critical discusses	The students learn fundamental concepts of network security. This includes risks and vulnerabilities of today's computer networks, concepts to increase the level of security in these networks, and a real-life priented introduction to encryption techniques, their applications and heir weaknesses. <u>oft skills</u> : Theoretical exercises to support in-depth understanding of lecture opics and to stimulate discussions, practical exercises in teamwork o support time management, targeted organisation of practical work					
Contents	Threats and attac pects: securing ne IPS (intrusion deto security protocols hash functions and encryption.	Threats and attack scenarios, organizational aspects, technical aspects: securing networks using different firewall concepts, IDS and IPS (intrusion detection systems and intrusion prevention systems), security protocols for different protocol layers, integrity protection: hash functions and their weaknesses, certificates, privacy protection, encryption.					
Frerequisites	High Performance	Networking (MA	-INF 31	<u>semester</u>) 01)	<u>.</u>		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises (Extensive practical of Network Security Lal	exercises in the o)	60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements	Exam(s)						
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media	A	<u> </u>					
Literature	 Christoph Busch, Akademischer Vei Matt Bishop: Intro 	Stephen D. Wol rlag oduction to Compu	thusen: uter Sec	Netzwerks urity, Addi	sicherheit, Sj son Wesley	oektrum	

Module name: Mobile Communi	Module name: Mobile Communication				universitätbonn			
Module No. MA-INF 3202	Workload 120 h	Credit points 4		Frequenc Every yea	y ar			
Module coordinator	Prof. Dr. Peter Ma	rtini						
Lecturer(s)	Dr. Matthias Frank	, Prof. Dr. Peter	Martin	i				
Classification	Prograr	Programme Com Of			Semes	ster		
	M.Sc. Computer S	cience	Optio	nal	2 nd sem.			
Targeted learning outcomes Contents	technical skills: Knowledge about mobility managem dependent), knowl tion with other pr ability to evaluate bile devices. In-de wireless/mobile sy small groups, stre solutions to curren soft skills: Theoretical exercise topics and to stim to support time m and critical discusse Mobility Managem sics, Wireless Netw	technical skills: Knowledge about key concepts of mobile communication including mobility management (both technology independent and technolog dependent), knowledge about wireless technologies and their interact tion with other protocol layers and/or other network technologies ability to evaluate and assess scenarios with communication of mo- bile devices. In-depth understanding of communication paradigms of wireless/mobile systems and network elements, productive work in small groups, strengthening skills on presentation and discussion of solutions to current challenges <u>soft skills</u> : Theoretical exercises to support in-depth understanding of lectur topics and to stimulate discussions, practical exercises in teamwor to support time management, targeted organisation of practical wor and critical discussion of own and others' results Mobility Management in the Internet, Wireless Communication Ba						
	Networks.							
Prerequisites	Required (exceptional High Performance	<u>ally not for studen</u> Networking (MA	<u>ts of 1st</u> -INF 31	<u>semester)</u> 01)	<u>):</u>			
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits		
	Lecture Exercises		60 30	2 1	30 T/30 S 15 P/45 S	2 2		
Exam achievements		Exa	m(s)					
(graded)	Oral exam							
Study achievements (not graded)	Successful exercis	e participation						
Forms of media								
Literature	 Jochen Schiller: Mobile Communications, Addison-Wesley, 2003 William Stallings: Wireless Communications and Networking, Prentice Hall, 2002 Further up-to-date literature will be announced in due course before the beginning of the lecture 							

Module name: Intelligent Information Systems				universitätbonn			
Module No. MA-INF 3203	Workload 240 h	Credit points 8		Frequency Every year			
Module coordinator	Prof. Dr. Rainer Ma	anthey					
Lecturer(s)	Prof. Dr. Rainer Ma	anthey					
Classification	Progran	Programme Comp Opt			Semest	er	
	M.Sc. Computer Science Optio		Optio	nal	2 nd or 3 rd se	m.	
largeted learning outcomes	technical skills: Students master t agement both theo application model state-of-the-art in r <u>soft skills</u> : Communicative sk tions), self-compet ity), social skills teams)	technical skills: Students master the principles of view, constraint and trigger man- agement both theoretically and in practical systems development and application modeling; they are able to understand and classify the state-of-the-art in research in active and deductive databases. <u>soft skills</u> : Communicative skills (oral/written presentation, "defending" solu- tions), self-competence (time management, self-organisation, creativ- ity), social skills (constructive discussion, sharing work in small					
Contents	Syntax and sema query processing trigger processing analysis of tempor	ntics of triggers in deductive DB ; soft and stron al data; IS desig	s, cons 3; rule-t g consi n for ru	traints based cl stency d le-based	and views; e hange manag checking; rule d applications	fficient ement; based	
Prerequisites	Recommended: Good knowledge of	f the foundations	s of SQI	_			
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises		60 30	4 2	60 T/90 S 30 P/60 S	5 3	
Exam achievements		Exa	m(s)	·			
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media							
Literature	 C. Zaniolo, S. Cer San Francisco/US E. Bertino, G. Za Wesley, 2001 	i et al.: Advanced SA, 1997 arri, B. Catania: I	Databas ntelliger	se Syster It Datab	ns, Morgan Kar ase Systems, .	ufmann, Addison	

Module name: Distributed and I	Module name: Distributed and Mobile Information Systems				universitä	tbonn	
Module No. MA-INF 3204	Workload 120 h	Credit points 4		Frequency Every 2 years			
Module coordinator	Dr. Thomas Bode						
Lecturer(s)	Dr. Thomas Bode						
Classification	Progran	nme	Com Op	oulsory/ tional	Semes	ster	
	M.Sc. Computer So	cience	Optior	nal	2 nd or 3 rd	sem.	
Targeted learning outcomes	technical skills: Solid understandir solving techniques <u>soft skills</u> : Communicative sk ing), personal skill:	<u>echnical skills</u> : Solid understanding of modern architecture concepts and problem solving techniques for distributed and mobile information systems. <u>soft skills</u> : Communicative skills (written and oral presentations, decision mak-					
Contents Prerequisites	System architectu peer-to-peer inforr sensor nets), trans system managed tion- and synchro mobile information Recommended:	System architectures (distributed and mobile data base systems, peer-to-peer information systems, data-grids, data management in sensor nets), transaction management, query evaluation techniques, system managed redundancy (semantic caching, hoarding, replication- and synchronization of data), spatial information handling in mobile information systems.					
·	Profound knowledg	ge in databases a	and info	rmation	systems		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises (Theoretical and pra- small groups)	ctical exercises in	60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media							
Literature	G. Coulouris, J. Doll Design. Addison Wes	G. Coulouris, J. Dollimore, T. Kindberg, Distributed Systems. Concepts and Design. Addison Wesley, June 2005					

Module name: Internet Informat	Module name: Internet Information Systems				universitätbonn			
Module No. MA-INF 3205	Workload 120 h	Credit points 4		Frequer Every y	ncy /ear			
Module coordinator	Dr. Stefan Lüttring	haus-Kappel						
Lecturer(s)	Dr. Stefan Lüttring	haus-Kappel						
Classification	Prograr	nme	Compu Optio	lsory/ onal	Semes	ster		
	M.Sc. Computer S	cience	Optiona		2 nd or 3 rd	sem.		
l argeted learning outcomes	technical skills: Profound knowledg and apply appropr <u>soft skills</u> : Ability to present dents; analytical a	technical skills: Profound knowledge of content management systems; ability to select and apply appropriate technologies and tools for web applications <u>soft skills</u> : Ability to present, evaluate, and discuss solutions with fellow stu-						
Proroquisitos	formats and mark and XSL, etc.; ser Java Servlet and mapping, content tions, common sys side programming practical exercises	formats and markup: XML, XHTML 2, CSS, SVG; style sheets: CSS and XSL, etc.; server-side technologies: CGI, template mechanisms, Java Servlet and JSP, application servers, middleware, database mapping, content management systems (CMS): technical founda- tions, common systems, extensions, XML-technologies in CMS; client- side programming, JavaScript, "Web 2.0"; selected additional topics; practical exercises related to the essential topics and tools						
i rerequisites	Basic knowledge o	f XML and Java						
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Lecture Exercises (To deepen and exte cluding programmin Java and selected op	nd insight, in- g assignments in pen source tools)	60 30	2 1	30 T/30 S 15 P/45 S	2 2		
Exam achievements		Exa	m(s)					
(graded)	Oral exam							
Study achievements (not graded)	Successful exercis	e participation						
Forms of media								
Literature	 Jeffrey Jackson: Prentice Hall 200 Heiko Wöhr: Web Selected chapters 	Web Technologie 7 Technologien. dpt 5 from other books	es: A Cor unkt.verlag s, various s	nputer g, 2004 system c	Science Pers documentatio	pective.		

Module name: Aspect-oriented Software Development				universitätbonn			
Module No. MA-INF 3206	Workload 120 h	Credit points 4		Frequency Every year			
Module coordinator	Dr. Günter Kniesel	Dr. Günter Kniesel					
Lecturer(s)	Dr. Günter Kniesel						
Classification	Prograr	Programme Compu Opti			Semest	er	
	M.Sc. Computer S	cience	Optior	nal	2 nd sem.		
outcomes	Ability to identify pact on software oriented (AO) solur AO-technique for a suitable AO technic <u>soft skills</u> : Teamwork, collabo	Ability to identify cross-cutting concerns (CCC), understand their impact on software development, the essence of the various aspect- oriented (AO) solution approaches, asses the adequacy of a particular AO-technique for a given CCC and modularize CCCs using the most suitable AO technique. <u>soft skills</u> :					
Contents	tions (introduction guage, sample as cross-language as fine-grained aspec concern mining, re aware refactoring, reasoning, early as	Cross-cutting concerns, join points, aspect effects, effect specifica- tions (introduction and advice), aspects, a widely-used aspect lan- guage, sample aspect application areas, generic aspect languages, cross-language aspects, symmetric aspects, domain-specific aspects, fine-grained aspects, dynamic aspects, aspect weaving technologies, concern mining, refactoring to aspects, refactoring of aspects, aspect- aware refactoring, aspect interference analysis, aspects and modular					
Prerequisites	None		-		T		
Format/workload/ credits	Teaching	format	Group size	Hours. week	Workload [h]	Credits	
	Lecture Exercises (Practical work in goup using state-of-the-art N guages, and methodolo	os of 2·4 students IDE tools, lan· ogies)	60 30	2	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded)	Oral or written (de	pending on num	ber of c	andidat	es)		
Study achievements (not graded)	Successful exercis	e participation					
Forms of media							
Literature	 Robert E. Filmar Oriented Software Communications Ramnivas Laddac 	n, Tzilla Elrad, Si e Development, Ac of the ACM, Volun l: AspectJ in Actio	obhán (Idison-W ne 44, Is n, Mann	Clarke, N Vesley, 20 ssue 10, ing Publ	Mehmet Aksit: 205 October 2001 ications, 2003	Aspect-	

Module name: Advanced Logic I	Programming			universitätbonn			
Module No. MA-INF 3207	Workload 120 h	Credit points 4		Frequency Every year			
Module coordinator	Prof. Dr. Armin B.	Prof. Dr. Armin B. Cremers					
Lecturer(s)	Prof. Dr. Armin B. Dr. Stefan Lüttring	Cremers, Dr. Gü haus-Kappel	inter Kr	niesel,			
Classification	Progran	nme	Com Op	pulsory/ otional	Semes	ster	
	M.Sc. Computer Se	cience	Optio	nal	2 nd or 3 rd	sem.	
Targeted learning outcomes	technical skills: Ability to master a clean but highly e competence in pro <u>soft skills</u> : Skills in written a ming assignments	technical skills: Ability to master advanced logic programing techniques and to write clean but highly efficient Prolog programs using these techniques; competence in problem solving using the declarative paradigm <u>soft skills</u> : Skills in written and oral presentation of the solutions to program- ming assignments, collaboration with other students in small teams					
Contents Prerequisites	Quick refresh of logic programming basics and a Prolog development environment, searching, understanding backtracking and the cut, context arguments, difference lists, data structures, constraint pro- gramming, meta-programming, meta-interpreters, partial evaluation, partial evaluation of meta-interpreters, efficient Prolog programming, logic program analysis.						
, , , , , , , , , , , , , , , , , , ,	Good knowledge of	f the foundations	s of Log	ic Progra	mming		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises (Weekly programmir Prolog, both individu teams)	ng assignments in Jally and in small	60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Oral exam Successful exercise	e participation					
Forms of media							
Literature	 L. Sterling, E. Sha Richard O'Keefe: 	apiro (ed.): The Ar The Craft of Prolog	t of Prol g, MIT P	og (2nd eo ress.	d.) MIT Press		

Module name:							
Model Driven Eng	gineering				universitä	tbonn	
Module No.	Workload	Credit points		Freque	Frequency		
MA-INF 3208	120 h	4		Every	year		
Module coordinator	Prof. Dr. Armin B.	Cremers					
Lecturer(s)	Dr. Günter Kniesel	, Prof. Dr. A. B. (Cremers		-		
Classification	Progran	nme	Compu Optic	lsory/ onal	Semes	ster	
	M.Sc. Computer Se	cience	Optiona		2 nd sem.		
Targeted learning outcomes	technical skills: Ability to understa assess the applica given problem. Ab <u>soft skills</u> : Teamwork, collabo	technical skills: Ability to understand and use MDA tools and techniques. Ability to assess the applicability of a particular MDA technique or tool to a given problem. Ability to understand advanced MDA literature. soft skills:					
Contents	structural and behavioural reflection, models and meta-models, UML and the meta-object facility (MOF), model driven architecture (MDA), model transformations, declarative and imperative model transforma- tion systems, model transformation analysis, composition and reuse of model transformations, compilation and optimization of model transformations, model-based testing, model driven methodologies, MDA applications and success stories, evaluation.						
Frerequisites	none		Group	Hours /			
credits	Teaching	format	size	week	Workload [h]	Credits	
	Lecture Exercises (Practical work in grou using state-of-the-art M guages, and methodolo	ps of 2-4 students IDE tools, Ian- ogies)	60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Oral exam Successful exercise	e participation					
Forms of media							
Literature	 David S. Frankel: Computing, John Modellgetriebene ment. dPunkt, 20 additional papers new field 	Model Driven Arch Wiley Softwareentwicklu 05 and articles reflec	nitecture: / ung, Techr cting the r	Applying hiken, Er apid dev	MDA to Entengineering, M velopment of	erprise anage- this	

Module name: Seminar Selected ment	Module name: Seminar Selected Topics in Communication Manage- ment Module No. Workload Credit points				universität bonn l			
Module No. MA-INF 3209	Workload 120 h	Credit points 4	Frequency Every semester					
Module coordinator	Prof. Dr. Peter Ma	rtini						
Lecturer(s)	Prof. Dr. Peter Ma	rtini						
Classification	Progran	Programme Compute Option		llsory/ onal	Semes	ster		
	M.Sc. Computer Se	cience	Optiona		2 nd and 3 ^r	^d sem.		
outcomes	Ability to understand new research results presented in original scien- tific papers. <u>soft skills</u> : Ability to present and to critically discuss these results in the frame- work of the corresponding area							
Contents	Current conference	e and journal pap	pers, curr	ent star	ndardization	drafts		
Prerequisites	<u>Required</u> : High Performance	Networking (MA	-INF 310	1)				
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Seminar		10	2	30 T/90 S	4		
Exam achievements		Exa	m(s)					
(graded)	Oral presentation							
Study achievements (not graded)	Regular participati	on, written repor	rt					
Forms of media								
Literature	The relevant literat vious semester	ure will be anno	unced tov	wards th	ne end of the	e pre-		

Module name: Seminar Advance	ed Topics in Infor	nation Manage	ement		universitä	tbonn
Module No. MA-INF 3210	Workload 120 h	Credit points 4		Frequency At least every year		
Module coordinator	Prof. Dr. Armin B.	Prof. Dr. Armin B. Cremers				
Lecturer(s)	Prof. Dr. Armin B. Dr. Stefan Lüttring	Cremers, Dr. Th haus·Kappel, Pr	omas E of. Dr.	Bode, Rainer Ma	anthey	
Classification	assification Programme Comp Op M.Sc. Computer Science Option		Com Op	pulsory/ otional	Semes	ster
			nal	2 nd and/or sem.	r 3 rd	
Targeted learning outcomes	Ability to acquire and evaluate advanced scientific literature; skills in didactic preparation as well as oral presentation of complex matters and latest research results; ability to evaluate and discuss presentations of fellow students, and to constructively deal with critical feedback of others					
Contents	search literature	opics in informa	ition sy	stems da	sed on mod	ern re-
Prerequisites	Required: Information Syster	ns Engineering (MA-INF	3102)		
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T/90 S	4
Exam achievements		Exa	m(s)			
(graded)	Oral presentation					
Study achievements (not graded)	Regular participati	on, written repo	rt			
Forms of media						
Literature	The relevant literat vious semester.	ure will be anno	unced	owards tl	he end of the	e pre-

Module name: Seminar Selected	d Topics in Sensor	Network	Resea	arch		univers	ität bonn
Module No. MA-INF 3211	Workload 120 h	Credit po 4	ints		Frequency of availability Every semester		
Module coordinator	Prof. Dr. Pedro Jos	Prof. Dr. Pedro José Marrón					
Lecturer(s)	Prof. Dr. Pedro Jos	é Marrón					
Classification	Programme Comp opt			oulsory/ Seme cional		nester	
	M.Sc. Computer Sc	ience		optior	nal	2 nd or 3	rd Sem.
outcomes Contents	Ability to understate entific papers. <u>soft skills</u> : Ability to present a work of the corresp Current conferenc	Ability to understand new research results presented in original sci- entific papers. <u>soft skills</u> : Ability to present and to critically discuss these results in the frame- work of the corresponding area					
	drafts			• •			
Prerequisites	<u>Required</u> : High Performance I	Networkin	g (MA-I	INF 31()1)		
Format/workload/ credits	Teaching forn	nat	Group size	Hours /week	Work	load [h]	Credits
	Seminar		10	2	30 T	/ 90 S	4
Exam achievements			Exam	า(ร)			
(graded)	Oral presentation						
Study achievements (not graded)	Regular participatio	on, writter	ı report				
Forms of media							
Literature							

Module name: Spatial Informati	on Systems			universitätbonn			
Module No. MA-INF 3301	Workload 120 h	Credit points 4		Frequency Every yea	y ar		
Module coordinator	PD Dr. Volker Stein	nhage					
Lecturer(s)	PD Dr. Volker Steir	nhage					
Classification	Programme Compulsory/ Seme Optional					ster	
	M.Sc. Computer So	cience	Optior	nal	3 rd sem.		
Targeted learning outcomes	technical skills: Understanding the information system schemes, geometr essing of spatial que soft skills: • Ability to rate physical cond • Ability to der given task • Ability to der given task • Ability to put on paper • Ability to pre plemention i	 <u>technical skills</u>: Jnderstanding the most important paradigms and methods of spatial nformation systems: spatial data types, geometric representation schemes, geometric algorithms, spatial access methods, and processing of spatial queries <u>soft skills</u>: Ability to rate different approaches on conceptual, logical and physical concepts of spatial information design Ability to derive a solution oriented problem formulation of a given task. Ability to cooparate in small groups on solving a given task. Ability to put a conceptual solution and its implemention down on paper Ability to present and discuss a conceptual solution and its implemention and its implemention. 					
Contents	objects, logical m rithms, spatial ac review of prototypi	tial information odels and query cess methods, cal commercial	system / langu process system:	ages, bas ages, bas sing of sp s	sentation of sic geometri patial querie	spatial c algo- es, and	
Prerequisites	None		-				
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises		60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Successful exercise	exam in excepti e participation	onal ca	ses)			
Forms of media							
Literature	Spatial Databases The Morgan Kaufm	with Application ann Series in Da	nes Vois s to GIS ata Mar	sard: 5. Morgar nagement	n Kaufmann Systems, 20	_ 001.	

Module name: Database Techni	ques for Event Mo	onitoring Syste	ms		universitä	tbonn	
Module No. MA-INF 3302	Workload 120 h	Credit points 4		Frequency Every yea	y ar		
Module coordinator	Prof. Dr. Rainer Ma	anthey					
Lecturer(s)	Prof. Dr. Rainer Ma	anthey					
Classification	Programme Com O			pulsory/ ptional	Semes	Semester	
	M.Sc. Computer S	cience	Optio	nal	2 nd or 3 rd	sem.	
Targeted learning outcomes	technical skills: Students will get ac support for event m tion and storage of analysis and proces niques from the are bases are introduce event monitoring iss <u>soft skills</u> : Communicative skill competence (time n (constructive discuss	technical skills: Students will get acquainted with basic issues in and methods of database support for event monitoring systems. Apart from methods for representa- tion and storage of events in a database, various algorithmic approaches to analysis and processing of data streams are introduced. In particular, tech- niques from the areas of active, deductive, and temporal and real-time data bases are introduced and discussed in relation with stream processing and event monitoring issues. <u>soft skills</u> : Communicative skills (oral/written presentation, "defending" solutions), self- competence (time management, self-organisation, creativity), social skills					
Contents	Architecture of an event-driven DBMS; types of events and event logs; repre- sentation and storage of data streams, index structures and query process- ing for data streams (in particular, continuous queries); views over data streams; active and deductive rules for processing and analyzing events; one-pass-algorithms, window functions and methods of update propagation; foundations of active, deductive, and temporal data base systems; prototypi-						
Prerequisites	None						
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises		60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media							
Literature	 C. Aggarwal (ed.): York/USA, 2007 A. Gupta, I.S. Munand Applications, N. Paton (ed.): Ac York/USA, 1999 	: Data Streams: M mick: Materializec NetLibrary Inc., 1 ctive Rules in Data	odels ai I Views: .998 base Sy	nd Algorith Technique stems, Sp	ims, Springer es, Implement ringer, New	, New ation,	

Module name: Seminar Enterpr	ise Software Engi	neering			universitä	tbonn	
Module No. MA-INF 3303	Workload 120 h	Credit points 4		Frequer Every y	Frequency Every year		
Module coordinator	Prof. Dr. Armin B.	Cremers					
Lecturer(s)	Prof. Dr. Armin B.	Cremers, Dr. Gü	inter Knie	sel			
Classification	Programme Compulsory/ Semes Optional				ster		
	M.Sc. Computer S	cience	Optiona	I 3 rd sem.			
Targeted learning outcomes	technical skills: Familiarity with an research. This mig or in depth explora <u>soft skills</u> : Ability to acquire a didactic preparation and latest researc tions of fellow so cal feedback of oth	Familiarity with an advanced domain of current software engineering research. This might include either a broad overview of a specific field or in depth exploration of new, breakthrough results. <u>soft skills</u> : Ability to acquire and evaluate advanced scientific literature; skills in didactic preparation as well as oral presentation of complex matters and latest research results; ability to evaluate and discuss presenta- tions of fellow students, and to constructively deal with criti- cal feedback of others.					
Contents	Selected topics in software engineering based on modern research results. The topics will either deepen one of the areas of the software engineering related lectures of the master program or introduce stu- dents to new, emerging topics of software engineering.						
Prerequisites	Required: Information Syster the following lectur Model-Driven Softw Aspect-Oriented So	ns Engineering (res: vare Engineering oftware Engineer	MA-INF 3 g (MA-INF ing (MA-I	102) ar 3208), NF 320	nd at least of	ne of	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Seminar		10	2	30 T/90 S	4	
Exam achievements (graded)	Oral presentation	Exa	m(s)				
Study achievements (not graded)	Regular participati	on, written repo	rt				
Forms of media							
Literature	Articles representi of each course inst	ng established a tance	nd new w	ork in t	he respectiv	e area	
T = Face-to-face tead	ching; S = Independer	nt study					

Module name: Lab Communica	Aodule name: .ab Communication and Communicating Devices Module No Workload				universitätbonn			
Module No. MA-INF 3304	Workload 240 h	Credit points 8		Frequer Every s	ncy semester			
Module coordinator	Prof. Dr. Peter Ma	Prof. Dr. Peter Martini						
Lecturer(s)	Prof. Dr. Peter Ma	rtini						
Classification	Programme Compu Opti			ilsory/ onal	Semester			
	M.Sc. Computer S	M.Sc. Computer Science		I	2 nd and/or 3 sem.	3 rd		
Targeted learning outcomes	technical skills: The students will carry out a practical task (project) in the context of communication systems, including test and documentation of the im- plemented software/system. soft skills:							
Contents	Selected topics close to current research in the area of communica- tion systems, network security, mobile communication and communi- cating devices.							
Prerequisites	<u>Required</u> : High Performance Network Security (Mobile Communic	Networking (MA (MA-INF 3201) a ation (MA-INF 3	A-INF 31(and/or 202)	01),				
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Lab (The majority of tas) in co-operation proje partners such as loc research organisatio	ks is embedded ects with external cal industry and ons)	8	4	60 T/180 S	8		
Exam achievements		Ex	am(s)					
(graded)	Oral presentation							
Study achieve- ments (not graded)	Regular participat	ion, written docu	umentati	on				
Forms of media								
Literature	The relevant litera ous semester.	ture will be anno	ounced to	owards ⁻	the end of the	previ-		

Module name: Lab Information	Systems			universitätbonn			
Module No. MA-INF 3305	Workload 240 h	Credit points 8		Frequency At least every year			
Module coordinator	Prof. Dr. Armin B.	nin B. Cremers					
Lecturer(s)	Prof. Dr. Armin B. Dr. Stefan Lüttring	Cremers, Dr. Th ghaus-Kappel, Pi	nomas Bo rof. Dr. R	ode, ainer M	anthey		
Classification	Program	Programme Compu Opti M.Sc. Computer Science Optiona		ilsory/ onal	Semest	er	
	M.Sc. Computer S				2 nd and/or 3 sem.	3 rd	
l argeted learning outcomes	technical skills: The students will information system mented software/s <u>soft skills</u> : Ability to properly readable document ing with others in classify ones own	The students will carry out a practical task (project) in the context of information systems, including test and documentation of the imple- mented software/system. <u>soft skills</u> : Ability to properly present and defend design decisions, to prepare readable documentation of software; skills in constructively collaborat- ing with others in small teams over a longer period of time; ability to classify ones own results into the state-of-the-art of the resp. area					
Contents	Varying selected t base- and informa	opics close to c tion systems.	current re	esearch	in the area c	of data-	
Format/workload/ credits	None Teaching	format	Group size 8	Hours /week	Workload [h]	Credits	
Exam achievements (graded)	Oral presentation	Ex	am(s)		00 17 100 3		
Study achieve- ments (not graded)	Regular participat	Regular participation, written documentation					
Literature	The relevant litera ous semester.	ture will be anno	ounced to	owards t	he end of the	previ-	

Module name: Lab Enterprise S	Software Engineer	ring		universitätbonn			
Module No. MA-INF 3306	Workload 240 h	Credit points 8		Frequer Every y	ncy rear		
Module coordinator	Prof. Dr. Armin B.	Prof. Dr. Armin B. Cremers					
Lecturer(s)	Prof. Dr. A. B. Cre	Prof. Dr. A. B. Cremers, Dr. Günter Kniesel					
Classification	Programme Compu Opti			ilsory/ onal	Semest	Semester	
	M.Sc. Computer S	cience	Optiona		2 nd or 3 rd se	em.	
outcomes	technical skills: Ability to participa customers, identif the workload, plar gress and adapt t art tools for softw management, test <u>soft skills</u> Effective collabora reach design and	Ability to participate in and run a software project, communicate with customers, identify and analyse requirements, identify risks, estimate the workload, plan iterations, keep the team involved, control the progress and adapt the process if necessary, choose and use state of the art tools for software development, issue management, configuration management, testing and integration. <u>soft skills</u> Effective collaboration in a small team including the ability to jointly reach design and management decisions.					
Contents	The course participants will work as a team on a joint project, apply- ing advanced software engineering concepts (e.g. SOA, MDE, AOSD) and related modern software development tools in the framework of an agile software development process (XP, Scrum, etc.).						
	Seminar Enterpris Information System Model-Driven Soft Aspect-Oriented S	Required: Seminar Enterprise Software Engineering (MA-INF 3303), Information Systems Engineering (MA-INF 3102) and at least one of Model-Driven Software Engineering (MA-INF 3208) or					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lab (Team of 10-12 stud "extreme programm – pair programming refactoring, test-firs	dents practicing ning" techniques , planning game, t, etc.)	8	6	90 T/150 S	8	
Exam achievements	Oral presentation	Ex	am(s)				
Study achieve- ments (not graded)	Regular participat	ion, written docı	umentati	on			
Forms of media							
Literature	"Extreme progra and literature pe course instance. MA-INF 3206, MA	mming explain rtaining to the See also the p ·INF·3208, MA·I	ed", Ker specific rerequis NF 3303	nt Beck topic c ite cou).	, Addison We of the respec rses (MA-INF	esley, tive 3102,	

 $T = Face \cdot to \cdot face teaching; S = Independent study$

Module name: Sensor Networks						universi	tät <mark>bonn</mark>
Module No. MA-INF 3307	Workload 120 h	Credit po 4	ints		Frequen Every ye	cy of avail ear	ability
Module coordinator	Prof. Dr. Pedro Jos	Prof. Dr. Pedro José Marrón					
Lecturer(s)	Prof. Dr. Pedro Jos	é Marrón					
Classification	Programme Compulsory/ Seme optional					nester	
	M.Sc. Computer Sc	cience		optior	al	3 rd Sem	
Targeted learning outcomes	technical skills: The students learn how they differ fro energy and resour ments, the studen networks and use of real-world phence soft skills: Communicative sk tions), self-compet ity), social skills teams)	The students learn the fundamental concepts of sensor networks and now they differ from traditional networked systems that do not take energy and resource constraints into account. During the experi- ments, the students will deal with real-world deployments of sensor networks and use real sensor nodes to understand better the effects of real-world phenomena in aspects like link quality, localization, etc. <u>soft skills:</u> Communicative skills (oral/written presentation, defending solu- cions), self-competence (time management, self-organisation, creativ- ty), social skills (constructive discussion, sharing work in small teams)					
Contents	Sensor network a platforms, operation link layer, transport ment.	rchitectur ng system ort layer,	es, sin is, MA(localiza	gle noo C proto ation, r	de arch ocols for niddlewa	itecture, ⁻ sensor are, data	hardware networks, manage-
Prerequisites	<u>Required</u> : High Performance	Networkin	g (MA-I	NF 310)1)		
Format/workload/ credits	Teaching forr	nat	Group size	Hours /week	Work	load [h]	Credits
	Lecture		60	2	30 T	/ 30 S	2
Even echievemente	Exercises		30	1	15 T	/ 45 S	2
Exam achievements	Oral exam		Exam	i(S)			
Study achievements (not graded)	Successful exercise	e participa	ition				
Forms of media							
Literature	 Holger Karl and A Sensor Networks" Feng Zhao and L Processing Approx 	ndreas Will , Wiley, 20 eo Guibas, ach", Morg	ig, "Pro 05. "Wirele an Kaufi	tocols a ss Sens mann, 2	nd Archit sor Netwo 2004	ectures fo orks: An I	r Wireless nformation

Module name: Seminar Selected	d Topics in Ubiqui	tous Corr	puting	ſ		univers	tät bonn
Module No. MA-INF 3308	Workload 120 h	Credit po 4	ints		Frequen Every se	cy of avail emester	ability
Module coordinator	Prof. Dr. Pedro Jos	é Marrón					
Lecturer(s)	Prof. Dr. Pedro Jos	é Marrón					
Classification	Progran	nme		Comp opt	ulsory/ ional	Sen	nester
	M.Sc. Computer Sc	cience		optior	nal	2 nd or 3	rd Sem.
	Ability to understa entific papers <u>soft skills:</u> Ability to present a work of the corresp	nd new re and to crit	esearch ically d rea	results	s presen these re	ted in or sults in t	iginal sci- he frame-
Contents	drafts.	e and jo	Jumai	papers	, currer	n stanu	aruization
Prerequisites	<u>Required</u> : High Performance	Networkin	g (MA-I	INF 31()1)		
Format/workload/ credits	Teaching forr	nat	Group size	Hours /week	Work	load [h]	Credits
	Seminar		10	2	30 T	/ 90 S	4
Exam achievements			Exam	n(s)			
(graded)	Oral presentation						
Study achievements (not graded)	Regular participatio	on, writter	n report	-			
Forms of media							
Literature							

Module Handbook

Master Programme "Computer Science"

Area of Competence

Intelligent Systems

MA-INF 4101	L4E2	8 CP	Theory of Sensorimotor Systems	RE
MA-INF 4102	L4E2	8 CP	Intelligent Learning and Analysis Systems	SW
MA-INF 4201	L2E1	4 CP	Artificial Life	RE
MA-INF 4202	L2E1	4 CP	Computational Neuroscience and Neural	RE
			Computation	
MA-INF 4203	L2E1	4 CP	Autonomous Mobile Systems	RE
MA-INF 4204	L2E1	4 CP	Technical Neural Nets	JA
MA-INF 4205	L2E1	4 CP	Probabilistic Graphical Models	ABC
MA-INF 4206	L2E1	4 CP	Knowledge-based Image Understanding	VS
MA-INF 4207	L2E1	4 CP	Dynamically Reconfigurable Systems	JA
MA-INF 4208	Sem	4 CP	Seminar Biological and Technical Neural	RE
			Computation	
MA-INF 4209	Sem	4 CP	Seminar Principles of Data Mining and Learning	SW
			Algorithms	
MA-INF 4210	Sem	4 CP	Seminar Advanced Topics in Technical	JA
			Informatics	
MA-INF 4301	L2E1	4 CP	Advanced Topics in Artificial Intelligence	ABC
MA-INF 4302	L2E1	4 CP	Advanced Learning Systems	SW
MA-INF 4303	L2E1	4 CP	Learning from Non-Standard Data	SW
MA-INF 4304	Lab	8 CP	Lab Development and Physical Realisation of	RE
			Sensory and Motor Modules	
MA-INF 4305	Lab	8 CP	Lab Autonomous Robots	ABC
MA-INF 4306	Lab	8 CP	Lab Development and Application of Data	SW
			Mining and Learning Systems	
MA-INF 4307	Lab	8 CP	Lab Field Programmable Gate Arrays	JA

(L: Lecture, E: Exercise, Sem: Seminar)

Module coordinators:

Joachim K. Anlauf (JA), Armin B. Cremers (ABC), Rolf Eckmiller (RE), Stefan Wrobel (SW), Volker Steinhage (VS)

Module name: Theory of Sensorimotor Systems								
Theory of Selisor	iniotor Systems					universi	latoonin	
Module No.	Workload	Credit point	S		Frequency			
MA-INF 4101 Module	240 II Prof Dr Armin B	0 Cremers				ear		
coordinator		Of efficitions						
Lecturer(s)	Prof. Dr. Rolf Eckm	niller, Dr. Nil	s Goe	erke		-		
Classification	Prograr	nme		Compı Opti	ulsory/ onal	Serr	nester	
	M.Sc. Computer Sc	cience		Option	al	1 st or 3 rd	^d sem.	
Targeted learning outcomes	technical skills: The students will be by means of sensorin part of a sensorimot art developments. Th ware project in small <u>soft skills</u> : Communicative skill sions in small team criticism, ability to a	<u>echnical skills</u> : The students will be capable to assess real world problems and application by means of sensorimotor approaches. They will be capable to identify wh part of a sensorimotor application might be improved by using state of the art developments. The student will learn how to plan and implement a so ware project in small working groups. <u>soft skills</u> : Communicative skills (oral and written presentation of solutions, discu- sions in small teams), self competences (ability to accept and formula						
Contents	Basic principles of le (e.g.: visually guided and technical examp vehicles); theories of autonomous system sensory systems, pla control systems. Pro architectures	Basic principles of learning sensorimotor systems with biological examples (e.g.: visually guided eye movements, auditory guided speech generation) and technical examples (e.g.: sensory guided processes, manipulators, or vehicles); theories of decision making and task planning; foundations of autonomous systems. Configuration, control, and functional principles of sensory systems, planning, decision, and motor systems as well as process control systems. Processing of sensory data; motor control; basic control architectures					examples generation) ulators, or dations of inciples of as process sic control	
Prerequisites	Recommended: Good knowledge of t puter science and pr	the foundation obability calc	ns of ulus	artificial	intellige	ence, tech	nical com-	
Format/workload/ credits	Teaching forr	mat G	aroup size	Hours /week	Work	load [h]	Credits	
	Lecture Exercises (Paper-and-pencil ex tasks with standard s and simulation syste Matlab, Simulink or I Work in 2- person gro	ercises, software ms like Labview. oups)	60 30	4 2	60 T 30 P	/ 90 S / 60 S	5 3 3	
Exam achievements			Exam	(s)				
(graded)	Written exam							
Study achievements (not graded)	Successful exercise	e participatio	on					
Forms of media Literature	 B. Widrow, S.D. S Englewood E.R. Kandel, J.H. S McGraw-Hill, New D.A. White, D.A. S and Adaptive Apple 	tearns: Adapt Schwartz, T.H York ofge: Handbo roaches, Van	ive Sig I. Jess ook of Nostra	gnal Pro el: Princ Intellige and Reir	cessing, ciples of nt Contro nhold, Ne	Prentice H Neural Sc ol: Neural, ew York	fall, ience, Fuzzy	

Module name:	ing and Analysis (Systems			univercität	A
	ing and Analysis	bystems		L L	IIIVEISILAL	
Module No. MA·INF 4102	Workload 240 h	Credit points 8		Frequency Every year		
Module coordinator	Prof. Dr. Stefan Wi	robel				
Lecturer(s)	Prof. Dr. Armin B. Prof. Dr. Stefan Wi	Cremers, PD Dr. robel	. Volker S	teinhag	e,	
Classification	Progran	nme	Compu Optic	llsory/ onal	Semes	ster
	M.Sc. Computer Se	cience	Optiona	I	1 st or 3 rd s	sem.
Targeted learning outcomes	technical skills: Students gain an uno ods of intelligent lead for implementing ad edge discovery in da pable of choosing a tions and use them start whenever adap is necessary. <u>soft skills</u> : Communicative skills in small teams), self ability to analyze pro	<u>achnical skills</u> : tudents gain an understanding of the most important paradigms and meth- ds of intelligent learning systems as they are used in data analysis and/or or implementing adaptive behaviour (machine learning, data mining, knowl- dge discovery in databases). At the end of the module, students will be ca- able of choosing appropriate methods and systems for particular applica- ions and use them to arrive at convincing results, and will know where to tart whenever adaptation or further development of algorithms and systems s necessary. <u>oft skills</u> : communicative skills (oral and written presentation of solutions, discussions n small teams), self competences (ability to accept and formulate criticism)				
Contents	lypes of learning a parametric methods ear methods, neura probabilistic approa learning theory, des groups), pre- and p special data types (visual systems	nd analysis tasks for supervised le al networks, neigh ches), clustering, scriptive data mir postprocessing, da spatial, network, t	, most im earning (e. nbourhooc reinforcen ning meth ata storag text, multi	nportant g., decis l methoo nent lear ods (ass e (data media d	non-paramet sion trees, ru ds, kernel m ning, evaluat sociation rule warehouses, ata), interact	tric and iles, lin- nethods, ion and es, sub- OLAP), tive and
Prerequisites	<u>Recommended</u> : Prior knowledge of gence information	probability theo	ory, linear	algebra	a, artificial in	ntelli-
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
Exam achievements	Lecture Exercises (Paper-and-pencil ex on-work on data ana popular software sys group work on comp	ercises, hands- lysis tasks with stems like Yale, R; petition projects)	60 30	4 2	60 T/90 S 30 P/60 S	5 3
(graded)	Written exam	LXd	11(3)			
Study achievements (not graded)	Successful exercise	e participation				
Forms of media						
Literature	 Tom Mitchell, M Ian Witten, Eibe Jiawei Han, Mic Techniques, Mo 	1achine Learning, Frank, Data Minir heline Kamber, Da rgan Kaufmann, 2	McGraw·H ng, Morgal ata Mining 2000	ill, 1997 n Kauffm : Concep	ann, 2000 ots and	

Module name: Artificial Life			universitätbonn				
Module No.	Workload	Credit points		Frequenc	V		
MA-INF 4201	120 h	120 h 4 Every 2 years					
Module coordinator	Prof. Dr. Rolf Eckn	niller					
Lecturer(s)	Prof. Dr. Rolf Eckn	niller, Dr. Nils Go	berke				
Classification	Prograr	nme	Com Op	pulsory/ ptional	Semes	ster	
	M.Sc. Computer Se	cience	Optio	nal	2 nd sem.		
Targeted learning outcomes	technical skills: Detailed understar ciples of artificial state of research in <u>soft skills</u> : Capability to ident sent and defend th group of students	nding of the mo life. Knowledge n the field of arti tify the state of ne found solution Critical discussi	st impo and u ficial lif the art ns with on of th	ortant ap nderstand e in artific in the exe ne results	proaches an ding of the ial life, and ercises in fro	to pre- ont of a	
Contents	Foundations of ar Life"; mechanisms ear dynamical sys and genetic algorit tems, adaptive be tems and swarm i	Foundations of artificial life, cellular automata, Conway's "Game of Life"; mechanisms for structure development; foundations of nonlin- ear dynamical systems, Lindenmeyer-systems, evolutionary methods and genetic algorithms, reinforcement learning, artificial immune sys- tems, adaptive behaviour, self-organising criticality, multi-agent sys-					
Prerequisites	Required:	Intelligence					
	Theory of Sensorin	notor Systems (N	MA-INF	4101)			
credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture Exercises (Paper-and-pencil ex person groups. Pres- cussion of the result cises. Small tasks to using state of the art and programms imp vidually (C++, JAVA,	ercises in two entation and dis- s during the exer- be completed t simulation tools, elemented indi-))	60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded) Forms of media	Oral exam Successful exercise	e participation					
Literature	 Christoph Adami: Science, TELOS, S Eric Bonabeau, M Natural to Artificia Studies in the Sci Andrzej Osyczka: sign Optimization Verlag, A Springe 	 Christoph Adami: Introduction to Artificial Life, The Electronic Library of Science, TELOS, Springer-Verlag Eric Bonabeau, Marco Dorigo, Guy Theraulaz: Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, Santa Fe Institute Studies in the Science of Complexity Andrzej Osyczka: Evolutionary Algorithms for Single and Multicriteria De- sign Optimization, Studies in Fuzzyness and Soft Computing, Physica- Verlag, A Springer-Verlag Company, Heidelberg 					

Module name: Computational Neuroscience and Neural Computation					universitä	tbonn	
Module No. MA-INF 4202	Workload 120 h	Credit points 4		Freque Every y	Frequency Every year		
Module coordinator	Prof. Dr. Rolf Eckn	niller					
Lecturer(s)	Prof. Dr. Rolf Eckn	niller, Dr. Nils Go	berke				
Classification	Program	nme	Compu Opti	ilsory/ onal	Semester		
	M.Sc. Computer S	cience	Optiona		2 nd sem.		
outcomes	technical skills: Knowledge of strue its elements; know simulate sensorim directional man-m sensorimotor syste <u>soft skills</u> : The students will I biological informa practise the interd with other subject ics).	technical skills: Knowledge of structure and function of biological neural systems and its elements; knowledge of biomimetic systems and modules, which simulate sensorimotor systems with neural control. Foundations of bi- directional man-machine interaction between a learning technical sensorimotor system and a human user. <u>soft skills</u> : The students will be capable to classify real world tasks by means of biological information processing paradigms. They will learn and practise the interdisciplinary communication by scientific discussions with other subjects (e.g. neuroscience, neuroanatomy, biocybernet-					
Contents	Structure and funct essing and learning ing: retina, sensory control theory, vecto for information proc of function and lear the definitions of info	ion of neural mod in specific regions cortex, cerebellur or analysis, tenso essing of sensory ning properties of ormation versus en	dules and s of the ce m, and m r calculus and moto neural sy ntropy.	elemen ntral ne otor cor , and Fo r brain stems.	ts. Informatic rvous system, rtex. Systems ourier transfo functions. Sin Relationship I	on proc- , includ- theory, rmation nulation between	
Format/workload/	Taaabiaa	fo was a t	Group	Hours		Quedite	
credits	leaching	format	size	/week	Workload [h]	Credits	
	Lecture60230 T/30 SExercises30115 P/45 S(Paper-and-pencil exercises, 3-5 exercises per week. Presentation of the results during the exercises in front of the group)1						
Exam achievements	Oral avam	Exa	m(s)				
(graueu)		nortinination					
(not graded)	Successiul exercise	participation					
Literature	 J.M. Bower: Computational Neuroscience: Trends in Research, Cal Tech Pasadena, Plenum Press, New York,1997 Simon Haykin: Neural Networks, A Comprehensive Foundation, Prentice Hall International Editions Christopher M. Bishop: Neural Networks for Pattern Recognition, Oxford University Press E.R. Kandel, J.H. Schwartz, T.H. Jessel: Principles of Neural Science, Macrow Hill, New York 						

Module name: Autonomous Mobile Systems				universitätbonn			
Module No. MA-INF 4203	Workload 120 h	Credit points 4		Frequency Every yea	Frequency Every year		
Module coordinator	Prof. Dr. Rolf Eckn	niller					
Lecturer(s)	Prof. Dr. Armin B.	Cremers, Prof. [Dr. Rolf	Eckmille	r, Dr. Nils Go	perke	
Classification	Program	nme	Com Op	pulsory/ otional	Semes	ster	
	M.Sc. Computer S	cience	Option	nal	2 nd sem.		
l argeted learning outcomes	technical skills: Profound knowledg function of learnin computational, ma sign of autonomou functional environr <u>soft skills</u> : The students will mobile systems. T plications might b The student will le in small working g	<u>echnical skills</u> : ² rofound knowledge of development and test regarding structure and function of learning, autonomous, mobile systems; Knowledge of the computational, mathematical, and technical requirements for the de sign of autonomous systems for specific applications and for specific functional environments <u>soft skills</u> : The students will be capable to assess applications for autonomous mobile systems. They will be capable to identify what part of the ap plications might be improved by using state of the art developments The student will learn how to plan and implement a software projec in small working groups.					
Prerequisites	Requirements for t e.g. for: map mak various principles ning. Comparison tions. <u>Required</u> :	the implementation king, dead recko of robot path p of different learr	ion of a pning, I plannin ning pa	ocalisatic ocalisatic g; metho radigms f	us mobile sy on, SLAM-m ds for actio or specific a	/stems, ethods, n plan- applica-	
E 17 11 17	Theory of Sensorin	notor Systems (N	MA-INF	4101)			
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Lecture60230 T/30 SExercises30115 P/45 S(Paper-and-pencil exercises, work in two person groups. Presentation, de- fending and discussion of the results during the exercises. Tasks with stan- dard software, simulation systems for autonomous mobile systems e.g. Labview, Stage & Gazebo and own60230 T/30 S						
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Oral exam Successful exercise	e participation					
Forms of media							
Literature	 JC. Latombe: Ro J. Buchli: Mobile botic Systems and 	bot Motion Planni Robots: Moving In d Pro Literatur Vei	ing, Klw telligeno rlag	er Academ ce, Publish	ic ied by Advand	ced Ro-	

Module name:						<u> </u>
Technical Neura	Nets				universitä	tbonn
Module No. MA-INF 4204	Workload 120 h	Credit points 4	Credit points Frequenc 4 Every ye			
Module coordinator	Prof. Dr. Joachim	K. Anlauf				
Lecturer(s)	Prof. Dr. Joachim	K. Anlauf, Prof. [Dr. Rolf E	ckmille	r, Dr. Nils Go	perke
Classification	Program	nme	Compu Optic	ilsory/ onal	Semes	ster
	M.Sc. Computer S	cience	Optiona		2 nd sem.	
Targeted learning outcomes	technical skills: Detailed knowledge of the most important neural network approaches and learning algorithms and its fields of application. Knowledge and understanding of technical neural networks as Non-Von Neumann computer architectures similar to concepts of brain functions at dif- ferent stages of development <u>soft skills</u> : The students will be capable to propose several paradigms from neu- ral networks that are capable to solve a given task. They can discuss the pro and cons with respect to efficency and risk. The will be capa- ble to plan and implement a small project with state of the art neural network solutions.					oaches ge and umann at dif- m neu- discuss e capa- neural
Prerequisites	ing maps (Kohonen) tion, recurrent netw Q-learning, support emplary application quality control, imag trol of technical proc hardware and softw ware.	adaptive resona orks, back-propag vector machines, is of neural nets ge processing, spe cesses and robots vare: tools, simula	ance theor ation of e pulse pro : function eech proce . Impleme ators, ana	ry, learn rror, rei cessing a approx essing, a ntation log and	ing vector q nforcement la neural netwo kimation, pre action plannin of neural netwo digital neura	antiza- earning, rks. Ex- ediction, ng, con- vorks in al hard-
Trerequisites	Intelligent Learning	and Analysis Syste	ems (MA-II	NF 4102)	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits
	Lecture60230 T/30 S2Exercises30115 P/45 S2(Paper-and-pencil exercises in 2- person groups. Presentation and dis- cussion of the results during the exer- cises. Small tasks to be completed using state of the art neural network susteme and programming libraries)60230 T/30 S2					
Exam achievements		Exa	m(s)	·		
(graded)	Oral exam					
Study achievements (not graded)	Successful exercis	e participation				
Literature	 Christopher M. Bi University Press, Ian T. Nabney: NE ISBN-10: 185233 	shop: Neural Netv ISBN-10: 0198538 TLAB. Algoriths fo 4401, ISBN-1 <u>3: 9</u>	vorks for F 8642, ISB or Pattern 78-18523	'attern F N-13: 97 Recogn 34406	Recognition, C 78-01985386 Ition, Springe	0xford 46 r,

Module name: Probabilistic Graphical Models					universitä	tbonn	
Module No. MA-INF 4205	Workload 120 h	Credit points 4	nts Frequency Every year				
Module coordinator	Prof. Dr. Armin B.	Cremers					
Lecturer(s)	Prof. Dr. Armin B.	Cremers					
Classification	Programme Compul Optio			ilsory/ onal	ry/ Semester I		
	M.Sc. Computer S	cience	Optiona		2 nd or 3 rd	sem.	
l argeted learning outcomes	technical skills: Participants acqui certain informatio how to design and inference task in the soft skills: Students should ac Ability to derive Ability to coopar Ability to put a c Ability to preser tion in an oral pr	 <u>echnical skills</u>: Participants acquire in depth knowledge of the representation of pertain information using probabilistic graphical models. They lean to design and apply different types of models to estimation a nference task in the context of sensorimotor systems. <u>soft skills</u>: Students should acquire the following skills: Ability to derive a solution oriented problem formulation of a given tas. Ability to cooparate in small groups on solving a given task. Ability to put a conceptual solution and its implemention down on pap Ability to present and discuss a conceptual solution and its implemention 					
Contents	This module introduce and ated inference and domain of sensorin Bayes filters, Hid rected models. <i>Inference:</i> (loopy) methods, and varia <i>Learning:</i> Bayesian	duces a selection d learning algori motor systems. den Markov Mo belief propagational methods. n learning and m	n of grap thms as Topics in odels, dyn on, junct odel sele	hical m well as clude: <i>I</i> namic ion tree ction te	odels, their application <i>Models:</i> Baye models, and es, MC and echniques.	associ- in the es nets, d undi- MCMC	
Prerequisites	Recommended: Intelligent Learning Sensorimotor Syster	and Analysis Syste ns (MA·INF 4102)	ems (MA-II	NF 4101) and/or Theo	ory of	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises		60 30	2 1	30 T/30 S 15 P/45 S	2 2	
Exam achievements		Exa	m(s)	1			
(graded)	Oral exam						
Study achievements (not graded)	Successful exercis	e participation					
Forms of media Literature	 M. I. Jordan: An I ration Daphne Koller, Ni tion F. V. Jensen: Bay M.I. Jordan (editor additional papers) 	ntroduction to Pro r Friedman: Bayes esian Networks an or): Learning in Gra	babilistic sian Netwo d Decisior aphical Mo	Graphic orks and n Graphs odels, M	al Models, in Beyond, in p s, Springer 20 IT-Press 1998	prepa- repara- 001 3	

Module name: Knowledge-based Image Understanding					universitä	tbonn	
Module No. MA-INF 4206	Workload 120 h	Credit points 4		Frequency Every year			
Module coordinator	PD Dr. Volker Stein	nhage					
Lecturer(s)	PD Dr. Volker Steir	nhage					
Classification	Prograr	Comp Opt	ulsory/ ional	Semester			
	M.Sc. Computer Se	cience	Optio	nal	2 nd sem.		
outcomes	 Understanding the edge-based image soft skills: Ability to rate concepts of sp Ability to derivitask Ability to coop Ability to put a per Ability to prestion in an oral 	 Understanding the most important paradigms and methods of knowledge-based image understanding systems <u>soft skills</u>: Ability to rate different approaches on conceptual, logical and physical concepts of spatial information design Ability to derive a solution oriented problem formulation of a given task Ability to cooparate in small groups on solving a given task. Ability to put a conceptual solution and its implemention down on paper Ability to present and discuss a conceptual solution and its implemention 					
Contents	Knowledge represe feature spaces, s graphical models. Rep, Multi-View, Ir down, feedback, h recognition. Active	entation and inf semantic networ Spatial and im ovariants. Interpr eterarchical. Co vision: salience,	erence rks, fra age-bas retatior mpone attent	about s ames, s sed obje strateg nt-basec on, trac	scenes and o cripts, fuzzy ct models: (jies: bottom-u l representati king.	bjects: / logic, 2SG, B- 1p, top- on and	
Prerequisites	None						
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture		60	2	30 T/30 S	2	
Exam achievements	Exercises	Exa	 m(s)		15 F/45 5	2	
(graded)	Oral exam						
Study achievements (not graded)	Successful exercise	e participation					
Forms of media Literature	 Larry S. Davis (Ed.): Foundations of Image Understanding. Series: The Springer International Series in Engineering and Computer Science, Vol. 628, Springer, 2001 David A. Forsyth, Jean Ponce: Computer Vision: A Modern Approach. Prentice Hall, 2003 Journal Computer Vision and Image Understanding, Editor-in-Chief: A.C. Kak. Elsevier 						

Module name: Dynamically Rec	Module name: Dynamically Reconfigurable Systems				universitätbonn			
Module No. MA-INF 4207	Workload 120 h	VorkloadCredit pointsFrequencyL20 h4At least every 2 ye				ars		
Module coordinator	Prof. Dr. Joachim	K. Anlauf						
Lecturer(s)	Prof. Dr. Joachim	K. Anlauf						
Classification	Prograr	nme	Compu Optic	lsory/ onal	Semes	ster		
	M.Sc. Computer Se	cience	Optiona	I	2 nd sem.			
outcomes	technical skills: Knowledge of the r appropriate FPGAs tools <u>soft skills</u> : Communicative sk cial skills (ability solution concepts) criticism, ability to	 <u>schnical skills</u>: nowledge of the most important FPGA architectures, ability to select ppropriate FPGAs for a given application, overview of programming pols <u>oft skills</u>: Communicative skills (oral and written presentation of solutions), so-ial skills (ability to solve problems in small teams, discussions of olution concepts) self competences (ability to accept and formulate ritiging, ability to accept and formulate 						
Contents	Architecture of FP Special Blocks, Ha ogy Mapping, Plac	GAs, Configurab Irdware Descript e and Route, Pai	le Logic E ion Langu rtial Reco	Blocks, Jages, nfigura	Wiring Ress Synthesis, T bility	ources, echnol-		
Prerequisites	None		-	[]				
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Lecture Exercises (Paper-and-pencil ex gramming tasks with scription languages and SystemC)	Lecture60230 T/30 S2Exercises30115 P/45 S2(Paper-and-pencil exercises, pro- gramming tasks with hardware de- scription languages such as VHDL115 P/45 S2						
Exam achievements		Exa	m(s)					
(graded)	Oral exam							
Study achievements (not graded)	Successful exercise	Successful exercise participation						
Forms of media								
Literature	Current research p	apers and techn	ical docu	mentat	ion			
Module name: Seminar Biologio	cal and Technical	Neural Compu	tation		universitä	tbonn		
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Module No. MA-INF 4208	Workload 120 h	Credit points 4		Frequency Every year				
Module coordinator	Prof. Dr. Rolf Eckn	niller						
Lecturer(s)	Prof. Dr. Joachim	K. Anlauf, Prof. [Dr. Rolf E	ckmille	r, Dr. Nils Go	berke		
Classification	Program	nme	Compu Opti	ilsory/ onal	Semes	ster		
	M.Sc. Computer S	cience	Optiona		2 nd sem.			
Targeted learning outcomes	technical skills: Detailed understar tion. Independent rent literature <u>soft skills</u> : The students will h subject. They will h lications for the giv content filter the for slides for a 45-60 lead the subseque	technical skills: Detailed understanding of the essential principles of neural computa- tion. Independent study of the fundamental principles based on cur- rent literature <u>soft skills</u> : The students will have learned to prepare and give a talk on the given subject. They will know how to find state of the art literature and pub- lications for the given subject, to comprehend the found items, and to content filter the found literature. They will be capable to prepare the slides for a 45-60 minutes talk. The give the presentation and can						
Contents	Principles of biological and biomimetic elements and systems. Struc- ture and function of selected neural systems (especially: retina, visual cortex, motor cortex, cerebellum). Principles of the most important technical neural net paradigms and learning algorithms and corre- sponding application areas. Selected approaches and typical applica- tions that represent the state-of-the-art							
Prerequisites	Required: Theory of Sensorin Intelligent Learning	notor Systems (N g and Analysis S	MA-INF 4 ystems (N	101) or MA-INF	4102)			
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Seminar		10	2	30 T/90 S	4		
Exam achievements		Exa	m(s)					
(graded)	Oral presentation							
Study achievements (not graded)	Regular participati	on, written repoi	rt					
Forms of media								
Literature	 R.J. Baron: The C Structure of the H London E.R. Kandel, J.H. McGraw-Hill, New P.S. Churchland, 	erebral Computer Iuman Brain, Lawr Schwartz, T.H. Jes York T.S. Sejnowski: Tr	: An Introc rence Erlb ssel: Princ ne Comput	aum, As iples of tational l	o the Comput sociates, Pub Neural Scienc Brain, MIT Pr	tational lisher, ce, ess		

Module name: Seminar Principles of Data Mining and Learning Algorithms				universitätbonn			
Module No. MA-INF 4209	WorkloadCredit points120 h4				Frequency Every year		
Module coordinator	Prof. Dr. Stefan Wi	robel					
Lecturer(s)	Prof. Dr. Stefan Wi	robel					
Classification	Prograr	nme	Compu Optic	ilsory/ onal	Semes	ter	
	M.Sc. Computer Se	cience	Optiona	I	2 nd or 3 rd	sem.	
Targeted learning outcomes Contents	technical skills: Enhanced and in-d machine learning dependently study cuss it with a know entifically present <u>soft skills</u> : Communicative sk tation of contents management with mulate criticism, a Theoretical, statis and learning algo	technical skills: Enhanced and in-depth knowledge in specialized topics in the area of machine learning and data mining, acquiring the competence to in- dependently study scientific literature, present it to others and dis- cuss it with a knowledgeable scientific auditorium. Learn how to sci- entifically present prior work by others, in writing <u>soft skills</u> : Communicative skills (preparing and presenting talks, written presen- tation of contents in a longer document), self competences (time management with long-ranging deadlines, ability to accept and for- mulate criticism, ability to analyse, creativity) Theoretical, statistical and algorithmical principles of data mining					
	cialized learning a	lgorithms from t	he frontie	er of res	search. Fund	damen-	
Prerequisites	tal results from ne	ignbouring areas	5.				
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Seminar		10	2	30 T/90 S	4	
Exam achievements	0	Exa	m(s)				
(graded)	Oral presentation						
(not graded)	Regular participati	on, written repoi	rt				
Forms of media							
Literature	The relevant literat vious semester.	ure will be anno	unced to	wards tł	ne end of the	e pre-	

Module name: Seminar Advanced Topics in Technical Informatics				universitätbonn			
Module No. MA-INF 4210	Workload 120 h	Credit points 4		Freque At leas	ncy st every 2 yea	ars	
Module coordinator	Prof. Dr. Joachim I	Prof. Dr. Joachim K. Anlauf					
Lecturer(s)	Prof. Dr. Joachim I	K. Anlauf					
Classification	Prograr	nme	Compulsory/ Optional		Semes	ster	
	M.Sc. Computer Sc	cience	Optiona		2 nd or 3 rd	sem.	
Contents	technical skills: Current Topics in T soft skills: Communicative sk structured written mulate criticism, (time management search topics from Current topics suc (field programmable system)	Technical Inform ills (preparing document), soc discussions of t with long-rang original literatu ch as: new arcl le gate arrays)	atics and pres ial skills current c ing deadl <u>re)</u> nitectures or new a	enting (ability ontent) ines, u of co pplicati	talks, prepa to accept a self compo nderstanding mputers or ons of dyna	aring a Ind for- etences g of re- FPGAs mically	
Prereguisites	None	.61115					
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Seminar		10	2	30 T/90 S	4	
Exam achievements (graded)	Oral presentation	Exa	m(s)				
Study achievements (not graded)	Regular participati	on, written repo	rt				
Forms of media							
Literature	Current research p	apers					

Module name: Advanced Topics	s in Artificial Intelli	gence			universitä	tbonn	
Module No. MA-INF 4301	Workload 120 h	Credit points 4		Frequency Every year			
Module coordinator	Prof. Dr. Armin B.	Cremers					
Lecturer(s)	Prof. Dr. Armin B.	Cremers					
Classification	Prograr	nme	Compu Optio	lsory/ onal	Semes	ter	
	M.Sc. Computer S	cience	Optiona		3 rd sem.		
Targeted learning outcomes Contents	 technical skills: Introduction of ad course aims at far search. soft skills: Students should ad Ability to derive task. Ability to coopa Ability to put a paper. Ability to prese plemention in a This class focuses 	 Introduction of advanced Artificial Intelligence (AI) techniques. This course aims at familiarising students with the latest trends in AI research. <u>soft skills</u>: Students should acquire the following skills: Ability to derive a solution oriented problem formulation of a given task. Ability to cooparate in small groups on solving a given task. Ability to put a conceptual solution and its implemention down on paper. Ability to present and discuss a conceptual solution and its implemention in an oral presentation. 					
Contents	current state of th soning, planning, l	e art in their res earning, and dec	spective a	area, e.g king.	g. perceptio	n, rea-	
Prerequisites	<u>Required</u> : Intelligent Learning ory of Sensorimoto	g and Analysis S or Systems" (MA-	ystems (N INF 4101	/A-INF /	4102) and/o	or The-	
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises		60 30	2 1	30 T/30 S 15 T/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded)	Oral exam						
Study achievements (not graded)	Successful exercis	e participation					
Forms of media							
Literature	 G. F. Luger: Artific M. Ghallab, D. Na additional papers 	cial Intelligence, 5 au, P. Traverso: Au	th edition, Itomated F	Addison Planning,	Wesley 2005 , Elsevier, 200	;)4	

Module name: Advanced Learni	ng Systems				universitä	A tbonn	
Madula Na	Workload	Cradit paints		Frequency			
MA-INF 4302	120 h	4		Every year			
Module coordinator	Prof. Dr. Stefan Wrobel						
Lecturer(s)	Prof. Dr. Stefan W	robel					
Classification	Program	Programme Compulsory/ Semester Optional					
	M.Sc. Computer Sci	ence	Optional		2 nd or 3 rd s	em.	
Targeted learning outcomes	technical skills: Participants specialize and require in-depth knowledge of one particular class of learning algorithms, they acquire the necessary knowledge to im- prove existing algorithms and construct their own within the given class, all the way up to the research frontier on the topic. <u>soft skills</u> : In group work, students acquire the necessary social and communication skills for effective team work and project planning, and learn how to present						
Contents	 The module consists of alternating lectures on different algorithm classes, including neural networks kernel machines probabilistic and statistical learning approaches logic-based learning approaches reinforcement learning 						
Prerequisites	Required: Intelligent Learning and Analysis Systems (MA-INF 4102) and/or Theory of Sensorimotor Systems" (MA-INF 4101) (Exceptions for students starting in the summer semester can be arranged after prior consultation only.)						
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lecture Exercises (Written exercises ar oriented work with s Learning Systems)	nd software- tate-of-the-art	60 30	2 1	30 T/30 S 15 T/45 S	2 2	
Exam achievements		Exa	m(s)				
(graded) Study achievements (not graded)	Oral exam Successful exercis	e participation					
Forms of media							
Literature	 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 Classification, John Wiley and Same, 2001 						

Module name: Learning from Non-Standard Data				universitätbonn				
Module No. MA-INF 4303	Workload 120 h	Credit points 4	Credit points 4			Frequency Every year		
Module coordinator	Prof. Dr. Stefan W	robel						
Lecturer(s)	Prof. Dr. Stefan W	robel						
Classification	Program	nme	Compu Opti	ilsory/ onal	Semes	Semester		
	M.Sc. Computer Sci	ence	Optional		2 nd or 3 rd s	em.		
Contents	Participants deepen particular non-stand ing increasingly imp requires specialized and postprocessing module. In group we cation skills for effe present software pro <u>soft skills</u> : Communicative skill in teams), self-comp to analyse, creativit The module will be f	Participants deepen their knowledge of learning systems with respect to one particular non-standard data type, i.e., non-tabular data, as they are becom- ing increasingly important in many applications. Each type of data not only requires specialized algorithms but also knowledge of the surrounding pre- and postprocessing operations which is acquired by the participants in the module. In group work, students acquire the necessary social and communi- cation skills for effective team work and project planning, and learn how to present software projects to others. <u>soft skills</u> : 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) The module will be filled with varying lectures on different non-standard data						
	from structured data, Spatial Data Mining							
Prerequisites	Required: Intelligent Learning and Analysis Systems (MA-INF 4102) and/or Theory of Sensorimotor Systems" (MA-INF 4101) (Exceptions for students starting in the summer semester can be arranged after prior consultation only.)							
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Lecture Exercises (Written exercises an oriented work with s Learning Systems)	nd software- tate-of-the-art	60 30	2 1	30 T/30 S 15 T/45 S	2 2		
Exam achievements	Oral exam	Exa	m(s)					
Study achievements (not graded)	Successful exercis	e participation						
Literature	 Gennady Andrienko, Natalia Andrienko, Exploratory Analysis of Spatial and Temporal Data, Springer, 2006 Diane J. Cook, Lawrence B. Holder, Mining Graph Data, Wiley & Sons, 2006 Saso Dzeroski, Nada Lavrac, Relational Data Mining, Springer, 2001 Sholom M. Weiss, Nitin Indurkhya, Tong Zhang, Fred J. Damerau, Text Mining. Predictive Methods for Analyzing Unstructured Information, Springer, 2004 							

Module name: Lab Development a Sensory and Motor	nd Physical Realisa Modules	ation	of		univers	sität bonn	
Module No. MA-INF 4304	Workload 240 h	Crec 8	lit points	Frequency Every year			
Module coordinator	Prof. Dr. Rolf Eckmi	ller		Livery your			
Lecturer(s)	Prof. Dr. Joachim K. Dr. Nils Goerke	Anlau	f, Prof. D	r. Rolf Eckn	niller,		
Classification	Programme Compu Opti			oulsory/ tional	Ser	nester	
	M.Sc. Computer Sci	ence	Optional		3 rd sem.		
Targeted learning out- comes	technical skills: Practical experience learning modules for mentation of functi with analog and digi <u>soft skills</u> : The students will le periments in 2-pers small working group ing assumptions in the results and write report the found re periments and to dr Principles of system	reconnical skills: Practical experience in design and implementation of adaptive and learning modules for the control of sensorimotor systems. Imple- mentation of functional elements for measurement and control with analog and digital electronic hardware <u>soft skills</u> : The students will learn how to design and conduct scientific ex- periments in 2-person groups. They will alternate in leading the small working group, analyze the results and evaluate the underly- ing assumptions in a scientific manner. They will learn to discuss the results and write documents that describe the experiments and report the found results. They will learn how to interpret the ex- periments and to draw conclusions.					
	systems. Implemen (e.g.: as mechanica implemented modul bot, manipulator, in capabilities of huma	tation I or m les for iverted	of selec echatroni several t pendulu inciples o	ted feedba c hardware est beds, e m, selected f adaptive a	ck contro), applica e.g.: autor l sensory and learnin	il modules tion of the iomous ro- and motor ng control	
Prerequisites	Required: Theory of Sensorimo Computational Neur 4202) and/or Technical Neural Ne	otor Sy oscien ts (MA	stems (M ce and No -INF 4204	A-INF 4101 eural Comp 4)), utation (N	1A-INF	
Format/workload/ credits	Teaching format	Grouj size	D Hour wee	rs/ Worl	kload [h]	Credits	
For a shirt second	Lab	8	4	60 T	/180 S	8	
(graded)	Oral presentation		Exam(S)			
Study achievements (not graded)	Regular participation	n, writ	ten docun	nentation			
Forms of media							
Literature	 D.A. White, D.A. So and Adaptive Appro M.M. Gupta, N.K. S plications, IEEE Pre 	fge: Ha baches, binha: li bess, Ne	ndbook of Van Nostr ntelligent (w York	Intelligent C and Reinhold Control Syste	ontrol: Neu d, New Yor ms, Theor	ıral, Fuzzy k y and Ap-	

Module name: Lab Autonomous	Module name: Lab Autonomous Robots			universitätbonn			
Module No. MA-INF 4305	Workload 240 h	Credit poir 8	nts	Frequency Every year			
Module coordinator	Prof. Dr. Armin B.	Cremers					
Lecturer(s)	Prof. Dr. Armin B.	Cremers					
Classification	Programme Compulsory/ Op- Semester tional						
	M.Sc. Computer So	cience	Optional		2 nd or 3 rd se	m.	
l'argeted learning outcomes	 technical skills: Students will gain different aspects o familiarize with th which are specific mobile robots. soft skills: Students should ad Ability to derive task. Ability to coopa Ability to put a paper. Ability to prese plemention in a 	experienc f control so e algorithm to the dep cquire the f e a solution arate in sm conceptua ent and dis	e in the de oftware for a ns involved loyment of c following ski oriented pr all groups o l solution ar scuss a con secuss a con	sign an autonom and lea complex lls: roblem f nd its in ceptual	d implementations robots. T rn to solve pr software syst formulation of g a given task. nplemention d solution and	ation of hey will oblems ems on a given own on its im-	
Contents	In this course stud robot control syste cific tasks. Typical map-building and planning.	tents will c ms which I tasks in t exploratio	lesign, imple enable robo his respect n, multi-rob	ement, a ts to aut are: aut oot coor	and evaluate r tonomously fu conomous nav dination and	parts of Ifil spe- igation, motion	
Prerequisites	Required: Theory of Sensorin Autonomous Mobil	notor Syste e Systems	ems (MA-INF (MA-INF 42	4101) 03)			
Format/workload/ credits	Teaching for	mat	Group size	Hours/ week	Workload [h]	Credits	
	Lab		8	4	60 T/180 S	8	
Exam achievements			Exam(s)				
(graded)	Ural presentation	····					
(not graded)	Regular participati	on, written	documenta	tion			
Forms of media							
Literature	 Sebastian Thrun, MIT Press, 2005 Howie Choset et a additional papers 	Wolfram Bu al.: Principle	rgard, Dieter s of Robot M	Fox: Pro	babilistic Robo T-Press, 2005	tics,	

Module name: Lab Development and Application of Data Mining and Learning Systems					universitätbonn			
Module No. MA-INF 4306	Workload 240 h	Credit points 8		Frequency Every year				
Module coordinator	Prof. Dr. Stefan Wi	robel						
Lecturer(s)	Prof. Dr. Stefan Wi	robel						
Classification	Prograr	nme	Compu Optio	llsory/ onal	Semes	ster		
	M.Sc. Computer S	cience	Optiona		3 rd sem.			
Contents	technical skills: Students will acquivelopment of intel data mining. They tems and apply the for the requirement <u>soft skills</u> : Communicative sidocumentation of teams), self-comp goals under limited to accept/formulation	<u>secnnical skills</u> : Students will acquire in-depth knowledge in the construction and de- velopment of intelligent learning systems for machine learning and data mining. They learn how to work with existing state-of-the-art sys- tems and apply them to application problems, usually extending them for the requirements of their particular task. <u>soft skills</u> : Communicative skills (appropriate oral presentation and written documentation of project results), social skills (ability to work in teams), self-competences (time management, aiming at long-range goals under limited ressources, ability to work under pressure, ability to accept/formulate ciriticsm)						
Contents	source framework specialized statist libraries for nume ods. User interfac analysis algorithm tous discovery sys	s for the const ical packages. F rical computation ces and visualion s for embeddeo tems.	ruction of Pre-proce on. Searc zation fo and dis	of data ssing t h and r analy tribute	analysis sy cools. Mather optimization sis systems d systems.	vstems, matical meth- s. Data Ubiqui-		
Prerequisites	<u>Required</u> : Theory of Sensorin Intelligent Learning	notor Systems (N g and Analysis S	MA-INF 43 ystems (N	101) or <u>//A-INF</u>	4102)			
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits		
	Lab (Working in small tea	ams)	8	2	30 P/210 S	8		
Exam achievements	Oral presentation	Exa	m(s)					
Study achievements (not graded)	Regular participati	on, written docu	mentatio	n				
Forms of media								
Literature	The relevant litera vious semester.	ture will be anno	ounced to	owards	the end of t	he pre-		

Module name: Lab Field-Progra	Module name: Lab Field-Programmable Gate Arrays				universitä	tbonn	
Module No. MA-INF 4307	Workload 240 h	Credit points 8		Frequency At least every 2 years			
Module coordinator	Prof. Dr. Joachim I	K. Anlauf					
Lecturer(s)	Prof. Dr. Joachim I	K. Anlauf					
Classification	Prograr	nme	Compu Optic	ilsory/ onal	Semes	ster	
	M.Sc. Computer Sc	cience	Optiona		2 nd or 3 rd	sem.	
	technical skills: Development and sexperience with sy from the idea to a grammable gate an <u>soft skills</u> : Communicative sk skills (ability to c concepts) self com ability to analyze a	Development and simulation of digital circuits in VHDL and SystemC, experience with synthesizable subsets, knowledge of the design path from the idea to a realized circuit implemented in an FPGA (field pro- grammable gate array) <u>soft skills</u> : Communicative skills (oral and written presentation of results), social skills (ability to cooperate in small teams, discussions of solution concepts) self competences (ability to accept and formulate criticism, ability to analyze and find practical solutions to problems)					
Contents	For Hardware Deso Subsets, Test of In	e Description, S cription, Simula oplementations o	imulation tion, and on FPGA	n, and S Synthe Evaluatio	ynthesis, Sy esis, Synthe on Boards	/stemC sizable	
Prerequisites	<u>Required</u> : Dynamically Recor	nfigurable Syster	ns (MA-IN	IF 4207)		
Format/workload/ credits	Teaching	format	Group size	Hours /week	Workload [h]	Credits	
	Lab		8	46	50 P/180 S	8	
Exam achievements (graded)	Oral presentation	Exa	m(s)				
Study achievements (not graded)	Regular participation, written documentation						
Forms of media							
Literature	Technical documer	ntation					

Module name: Master Thesis					universitä	tbonn	
Module No. MA-INF 0401	Workload 900 h	Credit points 30		Frequency Every semester			
Module coordinator	Prof. Dr. Rainer Ma	anthey					
Lecturer(s)	All lecturers of con	nputer science					
Classification	Programme C		Com Op	pulsory/ tional	Semes	Semester	
	M.Sc. Computer Se	M.Sc. Computer Science Compu		ulsory	4 th sem.		
l argeted learning outcomes	<u>technical skills</u> : Ability to solve a well-defined, significant research problem under su- pervision, but in principle independently <u>soft skills</u> : Ability to write a scientific documentation of considerable length ac- cording to established scientific principles of form and style, in par- ticular 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						
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits	
	Independent prepa scientific thesis wit coaching	Independent preparation of a scientific thesis with individual coaching			900 S	30	
Exam achievements		Exa	m(s)				
(graded)	Master Thesis						
Study achievements (not graded)	None						
Forms of media							
Literature	Individual bibliogra erature (depending	aphic research re g on the topic of	equired the the	for ident sis)	ifying releva	nt lit-	

Module name: Master Seminar					universitä	tbonn
Module No. MA-INF 0402	Workload 60 h	Credit points 2	Frequency Every semester			
Module coordinator	Prof. Dr. Rainer Ma	anthey				
Lecturer(s)	All lecturers of con	nputer science				
Classification	Programme Cor		Com Op	pulsory/ otional	Semes	ster
	M.Sc. Computer Science C		Compulsory		4 th sem.	
Targeted learning outcomes	Ability to document and defend the results of the thesis work in a sci- entifically appropriate style, taking into consideration the state-of-the- art in research in the resp. area					
	Topic, scientific co	ntext and result	s of the	master t	nesis	
Format/workload/ credits	Teaching	format	Group size	Hours/ week	Workload [h]	Credits
	Seminar		10	2	30 T/30 S	2
Exam achievements		Exa	m(s)			
(graded)	Oral presentation of	of final results				
Study achievements (not graded)	Regular participati	on, oral presenta	ation of	intermed	diate results	
Forms of media						
Literature	Individual bibliogra erature (depending	aphic research re g on the topic of	equired the the	for ident sis)	ifying releva	nt lit-