

# Mobile Robotics (M.Sc.)

**Agricultural Faculty** 

in cooperation with the

**Faculty of Mathematics and Natural Sciences** 

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Mobile Robotics (M.Sc.)

**General mandatory modules** 





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

Code: MA-MOROB-M01

Title: Introduction to Mobile Robotics

#### 1 Content and intended learning outcomes

#### Content

Robotic sensors; Odometry; Geometric and probabilistic motion models; Basic probabilistic models of range sensors; Environment models; Recursive Bayes filter, Kalman filter, and extended Kalman filter; Particle filter, Monte-Carlo localization; Simultaneous localization and mapping (SLAM); Main paradigms to solve SLAM (Kalman Filter, Particle Filters, Graph-based); P/PD/PID Controller; Model predictive control; Trajectory control; Planning; Motion planning; Roadmap planning; Markov decision processes.

#### Qualification goals:

Detailed comprehensive knowledge of state-of-the-art in state estimation, smoothing, and filtering with a key focus on trajectory as well as pose estimation; Specialized conceptual skills to be able to solve strategic problems in the field of mobile robotics.

#### 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Introduction to Mobile Robotics	en	30	2	90	W
Exercise, scientific	Introduction to Mobile Robotics	en	15	2	90	W
Lecture	Robot Planning and Control	en	30	1	45	W
Exercise, scientific	Robot Planning and Control	en	15	1	45	W

#### 3 Prerequisites to take part the module

obligatory:

none

recommended:

Basic programming skills in Python for completing homework assignments

#### 4 Study program allocation

Study program	(alternative) module code	mandatory / elective module	recommended semester
Mobile Robotics (M.Sc.)	MA-MOROB- M01	General mandatory selection	1st semester

### 5 Requirements for the rewarding of credits (ECTS)

Examination(s):

Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Written examination	written and/or verbal academic performance	120	graded	en	67%
Written examination	written and/or verbal academic performance	60	graded	en	33%

#### 6 Credits according ECTS

9 LP

#### 7 Workload

270 h

#### 8 Duration

1 semester

#### 9 Frequency

winter term

#### 10 Maximum number of students

no limitation

## 11 Module coordination

- 1								
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	-	C	u	ч		v	ı	

Name	Organization	SWS	exe.	res.
Prof. Dr. Cyrill Stachniss	Institut für Geodäsie und Geoinformation	2	Χ	Χ
Prof. Dr. Maren Bennewitz	Institut für Informatik	1	Χ	
Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	3	Χ	

#### Module coordinator / Organization:

Prof. Dr. Cyrill Stachniss (Institut für Geodäsie und Geoinformation)

#### 12 Further information

#### References:

- \* Thrun, Burgard, Fox: Probabilistic Robotics, MIT Press, 2005
- \* Corke: Robotics, Vision and Control, Springer, 2017
- \* LaValle: Planning Algorithms, Cambridge University Press, 2006, http://lavalle.pl/planning/
- \* Siciliano, Khatib (Eds): Springer Handbook of Robotics, 2nd edition

#### 13 Date of version

26.03.2024 (20252)





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

Code: MA-MOROB-M02
Title: Trajectory Estimation

#### 1 Content and intended learning outcomes

#### Content

Basic principle of Global Navigation Satellite Systems; Coordinate systems, GNSS signals and receiver technology; Observables, atmospheric effects, and multipath; Positioning procedures: Single point positioning, relative GNSS with carrier phases, precise point positioning; RTK GNSS; Network GNSS; Kinematic GNSS; GNSS attitude determination; GPS, GLONASS, Galileo, and Beidou; Trajectory estimation for mobile platforms; Sensors (inertial sensors, accelerometer, gyroscope, IMU, magnetometer, GNSS); Odometry; Inertial navigation; State Estimation algorithms; Kalman filter, Extended Kalman filter; Smoothing

#### Qualification goals:

Acquisition of advanced knowledge of the physical, functional, and stochastical characteristics of satellite-based positioning procedures and systems; In-depth knowledge of the structure and processing of GNSS signals; Skills in positioning with GNSS and performing absolute and relative GNSS measurements for static and kinematic applications; Understanding and interpretation of GNSS results and systematic deviations; Detailed comprehensive knowledge of state-of-the-art in state estimation, smoothing, and filtering with a key focus on trajectory as well as pose estimation

## 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Global Navigation Satellite Systems	en	30	1	45	W
Exercise, scientific	Global Navigation Satellite Systems	en	15	1	45	W
Lecture	Inertial Navigation Systems	en	30	1	45	W
Exercise, practical	Inertial Navigation Systems	en	15	1	45	W

#### 3 Prerequisites to take part the module

obligatory:

none

recommended:

none

#### 4 Study program allocation

Study program	(alternative)	mandatory / elective	recommended
	module code	module	semester
Mobile Robotics (M.Sc.)	MA-MOROB- M02	General mandatory selection	1st semester

#### 5 Requirements for the rewarding of credits (ECTS)

#### Examination(s):

Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Written examination	written and/or verbal academic performance	60	graded	en	50%
Written examination	written and/or verbal academic performance	60	graded	en	50%

#### 6 Credits according ECTS

6 LP

#### 7 Workload

180 h

#### 8 Duration

1 semester

#### 9 Frequency

winter term

10	Maximum number of students							
	no limitation							
11	Module coordination							
	Lecturer:							
	Name	Organization	SWS	exe.	res.			
	PD Dr. Lasse Klingbeil	Institut für Geodäsie und Geoinformation	2	Χ	Х			
	Team Prof. Kuhlmann	Institut für Geodäsie und Geoinformation	2	Χ				
	Module coordinator / Organization: Prof. Dr. Heiner Kuhlmann (Institut für Ge	andäsia und Capinformation						
12	Further information	eodasie und Geomormation)						
12	References:							
	* Paul D. Groves (2007): Principles of GNSS, Inertial and Multisensor Navigation Systems; Artech House Publishers, ISBN 1580532551, ISBN 13: 9781580532556							
13	Date of version							
	26.03.2024 (20252)							





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

Code: MA-MOROB-M03

Title: Python for Robotics and Computer Vision

#### 1 Content and intended learning outcomes

#### Content

In this course students will be introduced several of the basic ideas of programming and learn how to use it practically by using Python as the programming language. In the first half of the course, the students will become familiar with basic concepts such as variables, control statements, functions, modules (libraries), and object-oriented programming (classes). In the second half, the students will gain a deeper understanding of classes and also be introduced into scientific computing including data structures, manipulation of images (multi-dimensional arrays), advanced operators and insights into performing efficient operations in Python. The students are expected to be programming throughout the course so that they can practically demonstrate their knowledge by developing their own solutions and code.

#### Qualification goals:

Ability to convert problems into code (Python), principles of objects-oriented programming, and able to perform operations on multi-dimensional data. Problem solving and abstract thinking.

#### 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Python for Robotics & Computer Vision	en	30	2	90	W
Exercise, practical	Python for Robotics & Computer Vision	en	30	2	90	W

#### 3 Prerequisites to take part the module

obligatory:

none

recommended:

Prior programming experience is considered a plus.

#### 4 Study program allocation

Study program	(alternative) module code	mandatory / elective module	recommended semester
Mobile Robotics (M.Sc.)	MA-MOROB- M03	General mandatory selection	1st semester

#### 5 Requirements for the rewarding of credits (ECTS)

Examination(s):

Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Tasks accompanying the semester	written and/or verbal academic performance	-	graded	en	40%
Written examination	written and/or verbal academic performance	120	graded	en	60%

## 6 Credits according ECTS

6 LP

#### 7 Workload

180 h

#### 8 Duration

1 semester

## 9 Frequency

winter term

### 10 Maximum number of students

no limitation

#### Module coordination

Name	Organization	SWS	exe.	res.
Prof. Dr. Chris McCool	Institut für Landtechnik	3	Χ	Χ
Dr. Michael Halstead	Institut für Landtechnik	1	Χ	
Module coordinator / Organization Prof. Dr. Chris McCool	1:			
2 Further information				
none				
3 Date of version				





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

		nt and intended learn				
Title	<b>?</b> :	<b>Computer Vision</b>				
Cod	e:	MA-MOROB-M04				

#### ning outcomes

#### Content:

The class will cover a number of mathematical methods and their applications in computer vision. For example, linear filters, edges, derivatives, Hough transform, segmentation, graph cuts, mean shift, active contours, level sets, MRFs, expectation maximization, background subtraction, temporal filtering, active appearance models, shapes, optical flow, 2d tracking, cameras, 2d/3d features, stereo, 3d reconstruction, 3d pose estimation, articulated pose estimation, deformable meshes, RGBD vision.

#### Qualification goals:

Students will learn about various mathematical methods and their applications to computer vision problems. Productive work in small teams, development and realization of individual approaches and solutions, critical reflection of competing methods, discussion in groups.

#### 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Computer Vision	en	30	4	165	W/S
Exercise, scientific	Computer Vision	en	30	2	105	W/S

#### 3 Prerequisites to take part the module

obligatory:

none

recommended:

Basic knowledge of linear algebra, analysis, probability theory, Python programming

#### 4 Study program allocation

Study program	(alternative) module code	mandatory / elective module	recommended semester
Mobile Robotics (M.Sc.)	MA-MOROB- M04	General mandatory selection	1st semester
Cyber Security (M.Sc.)	MA-INF 2201	Elective selection	1st or 2nd se- mester
Computer Science (M.Sc.)	MA-INF 2201	Elective selection	1st or 2nd se- mester

#### 5 Requirements for the rewarding of credits (ECTS)

Examination(s):

Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Written examination	written and/or verbal academic performance	-	graded	en	100%

#### 6 Credits according ECTS

9 LP

#### 7 Workload

270 h

#### 8 Duration

1 semester

#### 9 **Frequency**

every term

#### 10 **Maximum number of students**

no limitation

#### 11 Module coordination

Lecturer:							
Name		Organization	SWS	exe.	res.		
Prof. Dr. J	irgen Gall	Institut für Informatik	6	Χ	Χ		
Module coo	rdinator / Organization:						
Prof. Dr.	Prof. Dr. Jürgen Gall (İnstitut für Informatik)						
12 Further info	Further information						
References:							
* R. Hartley	A. Zisserman: Multiple V	iew Geometry in Computer Vision					
* R. Szelisk	: Computer Vision: Algorit	thms and Applications					
* S. Prince:	Computer Vision: Models	s, Learning, and Inference					
13 Date of vers	ion						
26.03.2024	(20261)						





Cod										
Title	• •									
1	Content and intende	d learnin	g outcomes							
	Hierarchical optimative orientation;	nization a 3D senso	P; Graph-based simu pproaches; Visual fears, Laser scanners, ki n, mapping with UAV	atures; Featur inematic lase	re mat r scan	ching; ning,	; RANSAC; ( mobile map	Camera oping, s	a calibra system c	tion; Rel- alibra-
	Qualification goals:									
	Obtain advanced k	luding ef	e about the topics ab fective processing of							
2	Teaching and learning	ng metho	ds							
	Туре	Topic			La gua		Group- size	SWS	Work- load	Term
	Lecture	Graph S	SLAM		е	n	30	2	60	S
	Exercise, scien- tific/practical	Graph S	SLAM		е	n	15	1	45	S
	Lecture	3D Map			е	n	30	1	30	S
	Exercise, scientific	3D Map	pping		е	n	15	1	45	S
4	none recommended: MA-MOROB-M01; Study program alloc		OB-M02							
	Study program			(alternativ		man	datory / ele module	ective		mended
	Mobile Robotics (M	.Sc.)		module co MA-MORC M05				semester  2nd semester		
5	Requirements for the	e rewardi	ng of credits (ECTS)							
	Examination(s):									
	Туре		Prerequisites			Oura- tion	graded/ not grade		_an- uage	Weight
	Written examination	1	written and/or verb performance	al academic		120	graded		en	100%
6	Credits according EC	CTS								
7	Workload									
	180 h									
8	Duration									
9	1 semester									
9	Frequency summer term									
10	Maximum number of	students								
	no limitation					_				

1	octi	ırer.

2001011011				
Name	Organization	SWS	exe.	res.
Prof. Dr. Cyrill Stachniss	Institut für Geodäsie und Geoinformation	2	Χ	Χ
PD Dr. Lasse Klingbeil	Institut für Geodäsie und Geoinformation	0,5	Χ	
Prof. Dr. Heiner Kuhlmann	Institut für Geodäsie und Geoinformation	0,5	Χ	Х
Team Prof. Kuhlmann	Institut für Geodäsie und Geoinformation	1	Χ	
Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	1	Χ	

### Module coordinator / Organization:

Prof. Dr. Cyrill Stachniss, Prof. Dr.-Ing. Heiner Kuhlmann (Institut für Geodäsie und Geoinformation)

#### 12 Further information

#### References:

- \* Thrun, Burgard, Fox: Probabilistic Robotics, MIT Press, 2005
- \* Grisetti, Kümmerle, Stachniss, Burgard: A Tutorial on Graph-based SLAM, IEEE Transactions on Intelligent Transportation Systems Magazine, vol. 2, p. 31-43, 2010.
- \* Paul D. Groves (2007): Principles of GNSS, Inertial and multisensor navigation systems. Artech House Publishers, ISBN 1580532551, ISBN 13: 9781580532556

#### 13 Date of version

26.03.2024 (20261)





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

Code: MA-MOROB-M06

Title: Machine Learning for Robotics and Computer Vision

#### 1 Content and intended learning outcomes

#### Content

Introduction to machine learning covering supervised and unsupervised techniques in the context of robotics and computer vision; basic concepts of machine learning: classification, regression, clustering; Ensemble methods and boosting; Machine learning applications for computer vision and robotics; Deep learning with a focus on convolutional neural networks (CNN); Learning and techniques for training deep models; Common approaches for different perception tasks (classification, detection, semantic/panoptic segmentation); Current research topics: attention & transformer models for vision, contrastive learning for pre-training of visual representations

Qualification goals:

Ability to apply and implement machine learning algorithms for real tasks using Python & Pytorch

#### 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Machine Learning for Robotics and Computer Vision	en	30	2	90	S
Exercise, scientific	Machine Learning for Robotics and Computer Vision	en	30	2	90	S

## 3 Prerequisites to take part the module

obligatory:

none

recommended:

MA-MOROB-M03; MA-MOROB-M04

#### 4 Study program allocation

Study program	(alternative) module code	mandatory / elective module	recommended semester
Mobile Robotics (M.Sc.)	MA-MOROB- M06	General mandatory selection	2nd semester
Geodetic Engineering (M.Sc.)	MGE-MSR-03	Elective selection	2nd semester
Geodäsie und Geoinformation (M.Sc.)	M26	Fachgebundener Wahlpflichtbereich: Wahlpflichtmodul "groß"	2. Fachsemes- ter

#### 5 Requirements for the rewarding of credits (ECTS)

Examination(s):

<u> </u>					
Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Oral examination	written and/or verbal academic performance	25	graded	en	100%

#### 6 Credits according ECTS

6 LP

#### 7 Workload

180 h

#### 8 **Duration**

1 semester

## 9 Frequency

summer term

#### 10 Maximum number of students

	no limitation				
11	Module coordination				
	Lecturer:				
	Name	Organization	SWS	exe.	res.
	PD Dr. Jens Behley	Institut für Geodäsie und Geoinformation	2	Χ	Χ
	Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	2	Χ	
	Module coordinator / Organization:				
	PD Dr. Jens Behley (Institut für Geod	äsie und Geoinformation)			
12	Further information				
	Lectures and tutorials will take place in	person. Video recordings of lectures from past ye	ear(s) aı	re availa	able
13	Date of version				
	25.01.2024 (20261)				

# Mobile Robotics (M.Sc.)

**Project-related mandatory modules** 





Cod	de: <b>MA-MORO</b>	B-PS									
Titl	T		earch Part 1								
1	Content and intende	ed learnin	g outcomes								
	Content:	2		. <del> </del>			0: !!		P P	1	
			nation and localizatio n; Sensor fusion; Ad								
			ption; Semantic sens								
	Qualification goals:										
			the development of								
			s. Ability to systemat t the progress and pi								
	tations;	accamon	t the progress and pr	occine rocure		.0101111	no naj, roa	111 11011	.,	c procen	
2	Teaching and learning methods										
	Туре	Topic			La	ın.	Group-	SWS	Work-	Term	
					gua	age	size		load	1 -	
	Lab	Mobile	Robotics Research -	Part 1	е	n	30	4	180	S	
3	Prerequisites to tak	e part the	module								
	obligatory:										
	none										
	recommended:										
4	none										
4	Study program allo	cation		Π							
	Study program			(alternativ module co				ective	recommended semester		
	Mobile Robotics (N	1.Sc.)		MA-MOROE		General mandatory		atory	2nd semeste		
	mobile reserves (ii			WWW.WORKOE	selection				2114 00	11100101	
5	Requirements for the rewarding of credits (ECTS)										
	Examination(s):										
	Туре		Prerequisites		[	Dura-	graded/	L	_an-	Weight	
						tion	not grade	d g	uage		
	Project work		written and/or verb performance	al academic		•	graded		en	100%	
6	Credits according E	CTS				· ·					
	6 LP										
7	Workload										
	180 h										
8	Duration										
_	1 semester										
9	Frequency										
10	summer term	£ a4!!									
10	Maximum number of	or students	5								
11	no limitation	n									
11	Module coordinatio	TI .									

Name	Organization	SWS	exe.	res.
Prof. Dr. Cyrill Stachniss	Institut für Geodäsie und Geoinformation	2	Χ	Χ
PD Dr. Lasse Klingbeil	Institut für Geodäsie und Geoinformation	1	Χ	Χ
Prof. Dr. Heiner Kuhlmann	Institut für Geodäsie und Geoinformation	1	Χ	
Module coordinator / Organization:				
Prof. Dr. Cyrill Stachniss, Prof. Dr	r. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatic	n)	
Prof. Dr. Cyrill Stachniss, Prof. Dr  Further information	r. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatic	on)	
-	r. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatio	on)	
2 Further information	r. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatio	on)	





Cod	de: MA-MOROB	-PW									
Titl	e: Mobile Robo	otics Res	earch Part 2								
1	Content and intended	d learnin	g outcomes								
	Content:										
	mapping; Sensor of	calibratio	ation and localizatio n; Sensor fusion; Adv otion; Semantic sens	anced sensor	r data	interp	oretation; Po	ointclou	ud proces	ssing;	
	Qualification goals:										
	from the above-me	entioned <sup>3</sup>	ge in the developmen topics. Ability to syst ment the progress ar	ematically so	lve re	levant	problems in	n the c	ontext of		
2	Teaching and learning methods										
	Туре	Topic			La	an.	Group-	SWS	Work-	Term	
	31				gu	age	size		load		
	Lab	Mobile	Robotics Research -	Part 2	е	en	30	4	180	W	
3	Prerequisites to take	part the	module								
	obligatory: MA-MOROB-PS										
	recommended:										
4	Study program alloca	ation									
	Study program			module co				Ctive	semester		
	Mobile Robotics (M.	Sc.)		MA-MOROB	3-PW	Ger	neral manda selection	itory	3rd se	mester	
5	Requirements for the	rewardi	ng of credits (ECTS)								
	Examination(s):		-								
	Туре		Prerequisites			Dura- tion	graded/ not grade		_an- uage	Weight	
	Project work		written and/or verb performance	al academic		-	graded		en	67%	
	Written report		written and/or verb performance	al academic		-	graded		en	33%	
6	Credits according EC	CTS									
7	Workload										
	180 h										
8	Duration										
	1 semester										
9	Frequency										
	winter term										
10	Maximum number of	students	•								
	no limitation										
11	Module coordination										

Name	Organization	SWS	exe.	res.
PD Dr. Lasse Klingbeil	Institut für Geodäsie und Geoinformation	2	Χ	Χ
Prof. Dr. Cyrill Stachniss	Institut für Geodäsie und Geoinformation	1	Χ	Χ
Prof. Dr. Heiner Kuhlmann	Institut für Geodäsie und Geoinformation	1	Χ	
Module coordinator / Organization:				
	. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatic	n)	
	. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatio	on)	
Prof. Dr. Cyrill Stachniss, Prof. Dr.	. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatic	on)	
Prof. Dr. Cyrill Stachniss, Prof. Dr.  Further information	. Heiner Kuhlmann (Institut für Geodäsie und Geoinf	ormatio	on)	

# Mobile Robotics (M.Sc.)

Subject-related elective modules





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

	de: <b>MA-MOROB</b>	-E01								
Titl	e: <b>Agricultural</b>	Robotic	s and Phenotyping							
	Content and intended	d learnin	g outcomes							
	Content:									
			will take existing sy							
			udents will learn hov eal-world agricultura							
			ypic traits and the p							
	Qualification goals:									
			oot deployment in re						nd analy	sis. Ab
			n skills, teamwork,	critical discuss	sion of	metr	iods/algorit	hms		
	Teaching and learnin	ig metno	as		1				T	
	Туре	Topic			La		Group-	SWS	Work-	Term
	Exercise, practical	Acricul	tural Dahatias and [	Phonotypina	gua	Ĭ	size 15	3	load 120	S
	Seminar		tural Robotics and F tural Robotics and F		e e		20	1	60	S
				Heriotyping			20	1	00	3
	Prerequisites to take	part the	e module							
	obligatory:									
	none									
	recommended:		OB-M06 or compara	able experience	0					
	Study program alloca		OB-WOO OF COMPARA	anie experienc						
		111011		1 / 11 11		I		,. I		
	Study program			(alternation		mar	ndatory / ele module	ective	recomn	
	Mobile Robotics (M.	Sc.)		MA-MOROB		EI	ective select	ion		
	Requirements for the rewarding of credits (ECTS)  Examination(s):									
	Type		Prerequisites		Тг	oura-	graded/	Ті	.an-	Weight
	11 1300		Trerequisites			tion	not grade		ıage	Wolgiit
	Project work		written and/or ver	bal academic		-	graded		en	100%
			written and/or ver performance	bal academic		-	graded		en	100%
		CTS		bal academic			graded		en	100%
,	Project work	CTS		bal academic		-	graded		en	100%
	Project work  Credits according EC 6 LP  Workload	ETS .		bal academic			graded		en	100%
	Project work  Credits according EC 6 LP  Workload 180 h	TTS		bal academic		-	graded		en	100%
,	Project work  Credits according EC 6 LP  Workload 180 h  Duration	ETS		bal academic			graded		en	100%
,	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester	CTS		bal academic			graded		en	100%
	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency	ETS		bal academic			graded		en	100%
	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term		performance	bal academic			graded		en	100%
	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term  Maximum number of		performance	bal academic			graded		en	100%
0	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term  Maximum number of no limitation		performance	bal academic			graded		en	100%
0	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term  Maximum number of no limitation  Module coordination		performance	bal academic			graded		en	100%
0	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term  Maximum number of no limitation  Module coordination Lecturer:		performance				graded			
0	Project work  Credits according EC 6 LP  Workload 180 h  Duration 1 semester  Frequency summer term  Maximum number of no limitation  Module coordination	student	performance  S Org	bal academic  anization  itut für Landte	echnik		graded	SWS 2		100%

PD Dr. Lasse Klingbeil (Institut für Geodäsie und Geoinformation)

12	Further information
	none
13	Date of version
	26.03.2024 (20261)





Coc	le: MA-MOROB	-E02								
Title	e: <b>Humanoid R</b>	obotics								
1	Content and intended	d learnin	g outcomes							
			quares, 3D environm kinematics, whole-bo							
		nicative s	ed techniques for hui kills (oral and writte							
2	Teaching and learning	g metho	ds							
	Туре	Topic				an. age	Group- size	SWS	Work- load	Term
	Lecture	Human	Humanoid Robotics			en	30	2	75	S/W
	Exercise, scientific	Human	oid Robotics		е	en	15	2	105	S/W
4	obligatory: none recommended: MA-MOROB-M01 Study program alloca	ation								
4		ation		T						
	Study program			(alternative) module co	ode		ndatory / ele module			nended ester
	Mobile Robotics (M.			MA-MOROB			ective select			mester
	Computer Science (			MA-INF 42			ective select		2nd or me	ster
	Cyber Security (M.S	c.)		MA-INF 42	215	Ele	ective select	tion	2nd or me	3rd se- ster
5	Requirements for the Examination(s):	e reward	ing of credits (ECTS)							
	Туре		Prerequisites			Dura- tion	graded/ not grade		_an- uage	Weight
	Oral examination		written and/or verb performance (succe participation)		е	20	graded		en	100%
6	Credits according EC	TS								
7	Workload			_						
	180 h									
8	Duration									
0	1 semester									
9	Frequency									
10	every term  Maximum number of	studente	3							
10	no limitation	Judent	•							
11	Module coordination									

	Lecturer:				
	Name	Organization	SWS	exe.	res.
	Prof. Dr. Maren Bennewitz	Institut für Informatik	4	Χ	Χ
	Module coordinator / Organization:				
	Prof. Dr. Maren Bennewitz (Institut für Inf	ormatik)			
12	Further information				
	References:				
	* S. Thrun, W. Burgard and D. Fox: Probabili	stic Robotics. MIT Press, 2005.			
	* B. Siciliano, O. Khatib (Eds.): Springer Han	dbook of Robotics			
	* K. Harada, E. Yoshida, K. Yokoi (Eds.), Mot	ion Planning for Humanoid Robots, Springer			
	* Selected research papers.				
13	Date of version				
	26.03.2024 (20261)				





	de: MA-MORO	B-E03								
Titl		++ for Robotics and Computer	Vision							
1		ed learning outcomes								
_	Content:									
		C++; Revision control using git	; Solving typical	robotics	s tasks using	g C++, e	examples	s tasks		
	Qualification goals:									
	Detailed compre conceptual skills mapping; Use of	hensive knowledge in programr to solve typical robotics tasks revision control systems such oftware projects, also using dis	using C++ such as git. Work in sı	as point nall tea	cloud regist ms (typically	tration,	odomet	ry, and		
2	Teaching and learning methods									
	Туре	Topic		Lan- guage	Group- size	SWS	Work- load	Term		
	Lecture	Modern C++ for Robotics ar puter Vision		en	30	1	45	S		
	Exercise, scientific/practical	Modern C++ for Robotics ar puter Vision	nd Com-	en	15	2	75	S		
	Project	Modern C++ for Robotics ar puter Vision	nd Com-	en	20	1	60	S		
4	recommended: none  Study program allocation									
+										
	Study program		(alternative)		ndatory / ele	ective		mended		
			module code		module		sem	ester		
	Mobile Robotics (N	И.Sc.)	module code MA-MOROB-EC	)3 E		tion	seme 2nd se			
	Mobile Robotics (N	И.Sc.)	module code	93 E E F Wa	module lective selec	tion tion ner eich:	2nd se 2nd se 2nd se 2. Fach	ester mester mester		
5	Mobile Robotics (N Geodetic Engineer Geodäsie und Geo	M.Sc.) ing (M.Sc.)	module code MA-MOROB-EC MGE-MSR-03 M26	93 E E F Wa	module lective selec lective selec achgebunde ahlpflichtber /ahlpflichtmo	tion tion ner eich:	2nd se 2nd se 2nd se 2. Fach	mester mester mester semes-		
5	Mobile Robotics (N Geodetic Engineer Geodäsie und Geo	M.Sc.) ing (M.Sc.) information (M.Sc.) he rewarding of credits (ECTS)	module code MA-MOROB-EC MGE-MSR-03 M26	93 E E F Wa	module lective selective s	tion tion ener eich: odul	2nd se 2nd se 2nd se 2. Fach	mester mester mester semes-		
5	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo	M.Sc.) ing (M.Sc.) information (M.Sc.)	module code MA-MOROB-EC MGE-MSR-03 M26	93 E E F Wa	module lective selective s	tion tion ener eich: odul	2nd se 2nd se 2nd se 2. Fach te	mester mester mester semes-		
5	Mobile Robotics (National Repairments for the Examination(s):	M.Sc.) ing (M.Sc.) information (M.Sc.) he rewarding of credits (ECTS)	module code MA-MOROB-EC MGE-MSR-03 M26	P3 E F Wa W	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester isemes- er		
5	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo Requirements for the Examination(s): Type Oral examination Credits according E	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
6	Mobile Robotics (National Report Requirements for the Examination Second Requirements for the Examination Credits according Recording Regions Requirements for the Examination Regions	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
6	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo Requirements for the Examination(s): Type Oral examination Credits according E	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo Requirements for the Examination(s): Type Oral examination Credits according E 6 LP Workload	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
6	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo Requirements for the Examination(s): Type Oral examination Credits according E 6 LP Workload 180 h	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
6	Mobile Robotics (National Repairments for the Examination Second Second Requirements for the Examination Second Requirements for the Examination Second Repairments Repairment	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester semes- er Weight		
6 7 8	Mobile Robotics (I Geodetic Engineer Geodäsie und Geo Requirements for the Examination(s): Type Oral examination Credits according E 6 LP Workload 180 h Duration 1 semester	M.Sc.) ing (M.Sc.) information (M.Sc.)  he rewarding of credits (ECTS)  Prerequisites  written and/or verb performance	module code MA-MOROB-EC MGE-MSR-03 M26	Duration	module lective selective s	tion tion ener eich: odul	seme 2nd se 2nd se 2. Fach te	mester mester mester isemes er Weight		

no limitation										
Module coordination										
Lecturer:										
Name	Organization	SWS	exe.	res.						
Prof. Dr. Cyrill Stachniss	Institut für Geodäsie und Geoinformation	1	Χ	Х						
Dr. Tiziano Guadagnino	Institut für Geodäsie und Geoinformation	2	Χ							
Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	1	Х							
Prof. Dr. Cyrill Stachniss (Insti	Module coordinator / Organization: Prof. Dr. Cyrill Stachniss (Institut für Geodäsie und Geoinformation)									
2 Further information										
References:  * https://en.cppreference.com/w  * https://www.atlassian.com/git/										
13 Date of version										
26.03.2024 (20261)										



no limitation

## Master's Program Mobile Robotics (M.Sc.)



Coc	le: MA-MOROB	EO4								
Title		-								
1	1		g outcomes							
	Content and intended learning outcomes  Content:  Reinforcement learning, Markov decision processes, dynamic programming, Monte Carlo methods, temporal-difference methods, function approximation, linear quadratic regulation, differential dynamic programming, partially observable MDPs, policy gradient methods, inverse reinforcement learning, imitation learning, learning kinematic models, perceiving and handling of objects.									
2	Qualification goals:  Creating autonomous robots that can learn to assist humans in situations of daily life is a fascinating challenge for machine learning. The lecture covers key ingredients for a general robot learning approach to get closer towards human-like performance in robotics, such as reinforcement learning, learning models for control, learning motor primitives, learning from demonstrations and imitation learning, and interactive learning. Communicative skills (oral and written presentation of solutions, discussions in small teams), Self competences (ability to accept and formulate criticism, ability to analyze problems)									ch to get els for active
_	Teaching and learnin	_	u3				0	CIAIC		
	Туре	Topic		Ę		in- age	Group- size	SWS	Work- load	
	Lecture		_earning		е		30	2	75	W/S
	Exercise, scientific	Robot I	_earning		е	n	15	2	105	W/S
4	7. 0									
4		ation		(alternativ	(e)	man	datory / ele	ctive	recom	mended
4	Study program			(alternative module co	ode		datory / ele module		sen	mended nester
4		Sc.)			de -E04	Ele		ion	sem 2nd so 1st or	
4	Study program  Mobile Robotics (M.	Sc.) M.Sc.)		module co	ede -E04 .14	Ele Ele	module ective select	ion ion	sem 2nd se 1st or me 1st or	emester 2nd se-
5	Study program  Mobile Robotics (M. Computer Science (	Sc.) M.Sc.)	ing of credits (ECTS)	MA-MOROB MA-INF 41 MA-INF 41	ede -E04 .14	Ele Ele	module ective select ective select	ion ion	sem 2nd se 1st or me 1st or	emester  2nd seester  2nd seester
	Study program  Mobile Robotics (M. Computer Science ( Cyber Security (M.S	Sc.) M.Sc.)	ing of credits (ECTS)	MA-MOROB MA-INF 41 MA-INF 41	ode -E04 .14 .14	Ele Ele	module ective select ective select	ion ion	sem 2nd se 1st or me 1st or	emester 2nd seester 2nd seester
	Study program  Mobile Robotics (M. Computer Science ( Cyber Security (M.S  Requirements for the Examination(s):	Sc.) M.Sc.) c.)		module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Ele	module ective select ective select ective select graded/	ion ion	sem 2nd sem 1st or me 1st or me	emester 2nd se- ester 2nd se- ester
	Study program  Mobile Robotics (M. Computer Science ( Cyber Security (M.S. Requirements for the Examination(s):  Type	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd se- ester 2nd se- ester Weight
5	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S.))  Requirements for the Examination(s):  Type  Written examination  Credits according EC 6 LP	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd se- ester 2nd se- ester Weight
5	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S.))  Requirements for the Examination(S):  Type  Written examination  Credits according EC 6 LP  Workload	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd se- ester 2nd se- ester Weight
5 6 7	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S))  Requirements for the Examination(s):  Type  Written examination  Credits according EC 6 LP  Workload 180 h	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd se- ester 2nd se- ester Weight
5	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S))  Requirements for the Examination(S):  Type  Written examination  Credits according EC 6 LP  Workload 180 h  Duration	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd se- ester 2nd se- ester Weight
5 6 7 8	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S.))  Requirements for the Examination(s):  Type  Written examination  Credits according ECG 6 LP  Workload 180 h  Duration 1 semester	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd seester 2nd seester Weight
5 6 7	Study program  Mobile Robotics (M. Computer Science (Cyber Security (M.S))  Requirements for the Examination(S):  Type  Written examination  Credits according EC 6 LP  Workload 180 h  Duration	Sc.) M.Sc.) c.) e reward	Prerequisites written and/or verb performance (succe	module co MA-MOROB MA-INF 41 MA-INF 41	.14 .14	Ele Ele Dura- tion	module ective select ective select ective select graded/not graded	ion ion	sem 2nd so 1st or me 1st or me	emester 2nd seester 2nd seester Weight

11	Module coordination						
	Lecturer:						
	Name	Organization	SWS	exe.	res.		
	Prof. Dr. Sven Behnke	Institut für Informatik	4	Χ	Х		
	Module coordinator / Organization Prof. Dr. Sven Behnke (Institut f						
12	Further information						
	References:						
	* R. Sutton and A. Barto: Reinforcement Learning, MIT-Press, 1998.						
	* O. Sigaud and J. Peters (Eds.): Fr	om Motor Learning to Interaction Learning i	in Robots. Springe	er, 201	0.		
13	Date of version			•			
	29.04.2024 (20261)						





Cod	le: MA-MOROB	-E05								
Title			ics							
1	Content and intended									
_	Content:									
	Robot middleware (ROS), simultaneous localization and mapping (SLAM), 3D representations of objects								jects	
	and environments, object detection and recognition, person detection and tracking, action recognition, action planning and control, mobile manipulation, human-robot interaction.								on, ac-	
	Qualification goals:  Participants acquire practical experience and in-depth knowledge in the design and implementation of per-									
			hms for complex rob tion, and evaluate its							
			alyze problems and t							
			and written presenta							
2	Teaching and learning	g metho	ds							
	Туре	Topic			La	ın-	Group-	SWS	Work-	Term
					gua	age	size		load	
	Lab	Lab Co	gnitive Robotics		е	n	8	4	270	S/W
3	Prerequisites to take	part the	module							
	obligatory:									
	none									
	recommended:									
	MA-MOROB-E04									
4	Study program alloca	ation								
	Study program			(alternativ		man	idatory / ele	ective		nended
	M 1 11 D 1 11 (M	<u> </u>		module co			module			ester
	Mobile Robotics (M.			MA-MOROB		1	ective select		_	mester
	Computer Science (	IVI.SC.)		MA-INF 43	04	E1€	ective select	1011		3rd se- ster
	Cyber Security (M.S	c.)		MA-INF 43	804	Ele	ective select	tion	2nd or	
						mester				ster
5	Requirements for the	reward	ing of credits (ECTS)							
	Examination(s):									
	Туре		Prerequisites			Dura-	graded/		_an-	Weight
						tion	not grade		uage	1000
	Project work		none			•	graded		en	100%
6	Credits according EC	TS								
_	9 LP									
7	Workload									
	270 h									
8	Duration 1 semester									
9	Frequency									
9	every term									
10	Maximum number of	student	\$							
10	no limitation	Judoni								
11	Module coordination									
	1									

Lecture	:							
Name		Organization	SWS	exe.	res.			
Prof. D	r. Sven Behnke	Institut für Informatik	4	Х	Χ			
Module	coordinator / Organization:							
Prof.	Dr. Sven Behnke (Institut für Inforr	matik)						
12 Further	nformation							
Referen	References:							
* S. Thr	* S. Thrun, W. Burgard and D. Fox: Probabilistic Robotics. MIT Press, 2005.  * B. Siciliano, O. Khatib (Eds.): Springer Handbook of Robotics, 2008.							
* B. Sic								
* Select	ed research papers.							
13 Date of	version							
26.03.2	)24 (20252)							





Cod	le: MA-MOROE	3-E06								
Title			ts							
1	Content and intende	d learnin	g outcomes							
	Content: Robot middleward ning for humanoid		ion, state estimation	, environmen	t repr	resenta	ations, navig	gation, a	and moti	on plan-
	sentation, navigat pants analyze a p (time managemei	tion, and troblem, rat, goal-or ation skil	design and impleme motion planning tech ealize a solution, and riented work, ability t Is (collaboration in si entations).	iniques for hu d perform an o o analyze pro	mand exper oblem	oid rob imenta is theo	ots. In sma al evaluation retically and	all grou a. Self-c d to find	ps, the p competer d practica	artici- nces al solu-
2	Teaching and learni	ng metho	ds							
	Туре	Topic				an- iage	Group- size	SWS	Work- load	Term
	Lab	Lab Hu	manoid Robots		(	en	8	4	270	S/W
4	Prerequisites to tak obligatory: none recommended: MA-MOROB-E02 Study program alloc		. module							
	Study program			(alternation		mar	ndatory / ele module	ective	recomr	nended
	Mobile Robotics (N	I.Sc.)		MA-MOROB		El	ective selec	tion	2nd or mes	3rd se-
	Computer Science	(M.Sc.)		MA-INF 42	214	El	ective selec	tion	2nd or mes	
	Cyber Security (M.	Sc.)		MA-INF 42	214	El	ective selec	tion	2nd or mes	
5	Requirements for the Examination(s):	e reward	ing of credits (ECTS)							
	Туре		Prerequisites			Dura- tion	graded/ not grade		_an· uage	Weight
	Oral presentation		written and/or verb performance (succe ticipation, written r	essful lab par	-	20	graded		en	100%
6	Credits according E	СТЅ								
7	Workload									
	270 h									
8	Duration									
	1 semester									
9	Frequency									
10	every term									
10	Maximum number o		S							
11	Yes, limitation of 8 s  Module coordination									
11	module coordination									

	Lecturer:				
	Name	Organization	SWS	exe.	res.
	Prof. Dr. Maren Bennewitz	Institut für Informatik	4	Χ	Χ
	Module coordinator / Organization:				
	Prof. Dr. Maren Bennewitz (Institut für Inf	formatik)			
12	Further information				
	References:				
	* S. Thrun, W. Burgard and D. Fox: Probabili	stic Robotics. MIT Press			
	* B. Siciliano, O. Khatib (Eds.): Springer Han	dbook of Robotics			
	* K. Harada, E. Yoshida, K. Yokoi (Eds.), Mot	ion Planning for Humanoid Robots, Springer			
	* Selected papers.				
13	Date of version				
	09.04.2024 (20261)				





Cod		-E0/									
Title											
1	Content and intended	d learnin	g outcomes								
	Content: Computer Vision:	research	topics and app	olicatio	ons						
	Qualification goals:										
	The students will o										
	design decisions, to others in small tea	to prepar	e readable dod	umen Lof tir	tation of software	vare; s	Skills i fv one'	n construct	ively co	ollaborat the stat	ing with
	art of the resp. Are		a longer period	1 01 111	ne, ability to t	Jiassi	ly Offe	3 OWII I CSUI	13 11110	the stat	.6-01-1116-
2	Teaching and learning	g metho	ds							_	
	Туре	Topic				La gua	nn- age	Group- size	SWS	Work- load	Term
	Lab	Lab Vis	ion				n	8	4	270	S/W
3	Prerequisites to take	part the	module								
	obligatory: MA-MOROB-M04										
	recommended:										
	Good C++ or Pyth	on progra	amming skills								
4	Study program alloca										
	Study program				(alternativ	,	man	datory / ele	ective		mended
	Mobile Robotics (M.	Sc.)			module co		Fle	module ective select	ion		nester emester
	Computer Science (				MA-INF 23		-	ective select			3rd se-
	·									me	ester
5	Requirements for the	e rewardi	ing of credits (	ECTS)							
	Examination(s):		<u> </u>					T			
	Туре		Prerequisites				Dura- tion	graded/ not grade	_	Lan-	Weight
	Project work		none					graded	u g	guage en	100%
6	Credits according EC	TS									
	9 LP										
7	Workload										
	270 h										
8	Duration										
	1 semester										
9	Frequency										
	winter term										
10	Maximum number of	students	5								
	no limitation										
11	Module coordination										
	Lecturer:			0					014	, a l	
	Name	1			nization	. 121			SW		_
	Prof. Dr. Jürgen Gal			ınsti	tut für Inform	atık			4	Х	Х
	Module coordinator / Prof. Dr. Jürgen G	•		ik)							
12	Further information	, ,									
	none										

Date of version

26.03.2024 (20261)





Coc	de: MA-MOROB	-FN8								
Title			hotics							
1	Content and intended									
_	Content:									
	Current research p		m conferences and jons.	journals in the	e field	d of cog	gnitive robot	ics cov	ering fu	ndamen-
	Qualification goals:									
	learning. Ability to them in a research search, self-study)	understar talk as w , commun structured	rea of cognitive robout new research resell as in a seminar rication skills (prepad writing of seminar research results).	ults presented report. Self-co gration and cle	d in o mpe ear d	original tences idactic	scientific p (time mana presentatio	apers a gemen n of re	and to p t, literat search t	resent are alk, sci-
2	Teaching and learning	ng method	s							
	Туре	Topic				an- iage	Group- size	SWS	Work- load	Term
	Seminar	Seminar	Cognitive Robotics		(	en	10	2	120	S/W
3	Prerequisites to take	part the i	module							
	obligatory: none recommended: MA-MOROB-E04									
4	Study program alloca	ation								
	Study program			(alternativ module co		mar	ndatory / ele module	ctive		mended ester
	Mobile Robotics (M.	Sc.)		MA-MOROB-	-E08	Ele	ective select	ion	3rd se	mester
	Computer Science (	M.Sc.)		MA-INF 42	11	Ele	ective select	ion		3rd se- ster
	Cyber Security (M.S	c.)		MA-INF 42	11	Ele	ective select	ion		3rd se- ster
5	Requirements for the Examination(s):	e rewardin	g of credits (ECTS)							
	Туре		Prerequisites			Dura- tion	graded/ not graded		an- uage	Weight
	Seminartalk		none			45	graded		en	60%
	Written report		none			•	graded		en	40%
6	Credits according EC	CTS								
7	Workload									
	120 h									
8	Duration			_						
	1 semester									
9	Frequency									
	every term									
10	Maximum number of	students								
	no limitation									
11	Module coordination									

Lecturer:				
Name	Organization	SWS	exe.	res.
Prof. Dr. Sven Behnke	Institut für Informatik	2	Х	Χ
Module coordinator / Organ	ization:			
Prof. Dr. Sven Behnke (In	stitut für Informatik)			
12 Further information				
References:				
* S. Thrun, W. Burgard and	D. Fox: Probabilistic Robotics. MIT Press, 2005.			
* B. Siciliano, O. Khatib (Eds	s.): Springer Handbook of Robotics, 2008.			
* Selected papers.				
13 Date of version				
26.03.2024 (20261)				





0 1		<b>500</b>								
Cod			) a la a da							
Title										
1	Content and intended Content:	ı iearnin	g outcomes							
	· · · · · · · · · · · · · · · · · ·		om conferences and lications.	journals in the	e field	l of hu	manoid robo	otics c	overing f	unda-
	Qualification goals:									
	navigation, or moti sent them in a talk search, self-study), and experimental r	ion plann as well a commu results, s	area of humanoid ro ing. Ability to under as in a self-written su nication skills (prepa cientific discussion, n, critical examinatio	stand new resummary. Self- eration of the structured wr	earch comp talk, d iting d	result etence clear d of sum	ts of scientifes (time man idactic pres imary), socia	fic pap nagem entational al skill:	ers and tent, liter on of tec	to pre- ature hniques
2	Teaching and learnin			Ŭ		,		,		
	Туре	Topic				an- age	Group- size	SWS	Work- load	Term
	Seminar	Semina	r Humanoid Robots		е	n	10	2	120	S/W
3	Prerequisites to take	part the	module							
	obligatory: none									
	recommended: MA-MOROB-E02									
4	Study program alloca	ntion								
	Study program			(alternativ module co		mar	ndatory / ele module	ective		mended ester
	Mobile Robotics (M.Sc.)			MA-MOROB	-E09	Ele	ective select	ion		3rd se- ster
	Computer Science (M.Sc.)			MA-INF 42	13	Ele	ective select	ion		3rd se- ster
	Cyber Security (M.S	c.)		MA-INF 42	13	Ele	ective select	ion		3rd se- ster
5	Requirements for the	rewardi	ng of credits (ECTS)							
	Examination(s):						1			
	Туре		Prerequisites			Oura- tion	graded/ not graded		_an- uage	Weight
	Seminartalk		written and/or verb performance (succe participation)		r	25	graded		en	70%
	Written report		written and/or verb performance (succe participation)		r	-	graded		en	30%
6	Credits according EC	TS								
	4 LP									
7	Workload									
	120 h									
8	Duration									
	1 semester									
9	Frequency									
10	every term	الاستاد المساهم								
10	Maximum number of	students								

	Yes, limitation of 10 students				
11	Module coordination				
	Lecturer:				
	Name	Organization	SWS	exe.	res.
	Prof. Dr. Maren Bennewitz	Institut für Informatik	2	Χ	Χ
	Module coordinator / Organization:				
	Prof. Dr. Maren Bennewitz (Institut für Int	formatik)			
12	Further information				
	References:				
	* S. Thrun, W. Burgard and D. Fox: Probabil	istic Robotics. MIT Press			
	* B. Siciliano, O. Khatib (Eds.): Springer Har	ndbook of Robotics			
	* K. Harada, E. Yoshida, K. Yokoi (Eds.), Mot	tion Planning for Humanoid Robots, Springer			
	* Selected papers.				
13	Date of version				
	27.03.2024 (20261)				





Cod										
Title										
1		ed learning outcomes								
	Current conference	ce and journal papers.								
	Qualification goals:	ce and journal papers.								
	-	and new research results	s prese	ented in origi	nal so	eientific	papers. Ab	ility to	presen	t and to
		these results in the fram							p. 555	
2	Teaching and learni	ng methods								
	Туре	Topic				an- age	Group- size	SWS	Work load	Term
	Seminar	Seminar Vision				en	10	2	120	S/W
3	Prerequisites to tak	e part the module								
	obligatory:									
	MA-MOROB-M04									
	recommended: none									
4	Study program allog	ation								
	Study program			(alternativ	(O)	mar	ıdatory / ele	octivo	rocom	ımended
	Study program			module co		IIIai	module	ective		nester
	Mobile Robotics (M	l.Sc.)		MA-MOROB	-E10	Ele	ective select	ion	3rd s	emester
	Computer Science	(M.Sc.)		MA-INF 22	206	Ele	ective select	ion		r 3rd se- ester
5	Downing was a to fave the	a vavording of avadita (	FOTC:							
5	Examination(s):	e rewarding of credits (	EC (S)							
	Type	Prerequisites				Dura-	graded/		_an-	Weight
	1,700	7 707044107000				tion	not grade		uage	Wolght
	Seminartalk	none				45	graded		en	80%
	Written report	none				-	graded		en	20%
6	Credits according E	СТЅ								
	4 LP									
7	Workload									
	120 h									
8	Duration									
	1 semester									
9	Frequency every term									
10	Maximum number o	f students								
10	no limitation	1 Students								
11	Module coordination	1								
	Lecturer:									
	Name		Orga	nization				SW	S exe	res.
	Prof. Dr. Jürgen Ga	all	Insti	tut für Inform	atik			2	Х	Х
	Module coordinator	/ Organization:			_					
	Prof. Dr. Jürgen (	Gall (Institut für Informat	ik)							
12	Further information									
	none									

13	Date of version

26.03.2024 (20261)





Cod	e: <b>MA-MORC</b>	B-E11									
Title	e: Seminar M	/lobile Rob	otics								
1	Content and intend	led learnin	g outcomes								
	Content:			4							
	Original research		the context of r	TODOT	perception						
	Qualification goals: Ability to unders		esearch results	nres	ented in origir	nal s	cientific	naners Ah	vility to	nresen	t and to
	critically discuss								ility to	presen	t and to
2	Teaching and learn	ing metho	ds								
	Туре	Topic				L	.an-	Group-	SWS	Work-	Term
						gı	ıage	size		load	
	Seminar	Mobile	Robotics				en	10	2	90	W
3	Prerequisites to ta	ke part the	module								
	obligatory:										
	none										
	recommended:										
	MA-MOROB-M01		OB-M04								
4	Study program allo	cation			T		_			1	
	Study program				(alternativ		mar	ndatory / ele	ective		mended
	Mahila Dahatiaa (	M C - \			module co			module			nester
	Mobile Robotics (				MA-MOROB	-E11	EI	ective select	ION	3ra se	emester
5	Requirements for t	he reward	ing of credits (E	CTS)							
	Examination(s):		I						1 .		
	Туре		Prerequisites				Dura- tion	graded/ not grade		Lan∙ uage	Weight
	Colloquium		none				30	graded	9	en	100%
6	-	FCTC							ı		70
0	Credits according I	LUIS									
7	Workload										
	90 h										
8	Duration										
	1 semester										
9	Frequency										
	winter term										
10	Maximum number	of student	5								
	no limitation										
11	Module coordination	on									
	Lecturer: Name			Orga	ınization				SW	S exe	ros
	Prof. Dr. Cyrill Sta	achniss			tut für Geodäs	sie III	nd Geo	information	2		. res.
	Module coordinator	r / Organiz	ation:					morriation			
12	Further information			4510	and decimon	. iatio	,				
	none	· <del>-</del>									
13	Date of version										
	26.03.2024 (2026)	1)									
I.	` `	•									





Mobile Robotics (M.Sc.)   MA-MOROB-E12   Elective selection   3rd set	
Content: This course explores advanced concepts in deep learning. Throughout the course the students will lectures to provide background material on selected topics in the area of deep learning. To make the ing concrete, the students will then read, discuss and present related papers on these topics in the a short presentation (seminar). Additionally, during the course code will be developed for some of the techniques (in Python).  Qualification goals: Deeper insights into selected deep learning techniques. Abstract thinking, presentation skills, team critical discussion of methods/algorithms  2	
Content: This course explores advanced concepts in deep learning. Throughout the course the students will lectures to provide background material on selected topics in the area of deep learning. To make the ing concrete, the students will then read, discuss and present related papers on these topics in the a short presentation (seminar). Additionally, during the course code will be developed for some of the techniques (in Python).  Qualification goals: Deeper insights into selected deep learning techniques. Abstract thinking, presentation skills, team critical discussion of methods/algorithms  2	
lectures to provide background material on selected topics in the area of deep learning. To make topics in the a short presentation (seminar). Additionally, during the course code will be developed for some of it techniques (in Python).  Qualification goals:     Deeper insights into selected deep learning techniques. Abstract thinking, presentation skills, team critical discussion of methods/algorithms    Teaching and learning methods	
Deeper insights into selected deep learning techniques. Abstract thinking, presentation skills, team critical discussion of methods/algorithms  Type Topic Lan-guage size Work-load Lecture Advanced Deep Learning en 30 1 60 Exercise, scien-littic/practical Advanced Deep Learning en 30 3 120 thick/practical site/practical	is learn- form of
Deeper insights into selected deep learning techniques. Abstract thinking, presentation skills, team critical discussion of methods/algorithms  Type Topic Lan-guage size Workload Lecture Advanced Deep Learning en 30 1 60 Exercise, scien- Advanced Deep Learning en 30 1 1 60 Exercise, scien- Advanced Deep Learning en 30 3 120 stiftc/practical stiftc/practical en 30 3 120 stiftc/practical en 30 3 120 stiftc/practical en 30 3 3 120 stiftc/practical en 30 3 3 120 stiftc/practical en 30 8 stiftc/practical en	
Type Topic Lan-guage size SWS Work-load Lecture Advanced Deep Learning en 30 1 60 Exercise, scien-tific/practical Advanced Deep Learning en 30 3 120  Type Advanced Deep Learning en 30 3 120  Prerequisites to take part the module obligatory: MA-MOROB-MO3 recommende: none  4 Study program (alternative) mandatory / elective recommende module code module sem Mobile Robotics (M.Sc.) MA-MOROB-E12 Elective selection 3rd set Ma-MOROB-E12 Elective sel	work,
Lecture	
Exercise, scientific/practical Advanced Deep Learning en 30 3 120  Prerequisites to take part the module obligatory:     MA-MOROB-M03 recommended:     none  Study program (alternative) mandatory / elective recommodule code module code module sem Mobile Robotics (M.Sc.) MA-MOROB-E12 Elective selection 3rd set  Requirements for the rewarding of credits (ECTS)  Examination(s):  Type Prerequisites Duration not graded guage Project work written and/or verbal academic performance Oral examination written and/or verbal academic performance 25 graded en performance  6 Credits according ECTS 6 LP  7 Workload 180 h  8 Duration 1 semester  9 Frequency winter term  10 Maximum number of students no limitation  1 Maximum number of students no limitation	Term
tific/practical  Prerequisites to take part the module obligatory: MA-MOROB-MO3 recommended: none  Study program (alternative) mandatory / elective recommodule code module sem module code module sem module Robotics (M.Sc.)  MA-MOROB-E12 Elective selection 3rd set  Requirements for the rewarding of credits (ECTS)  Examination(s):  Type Prerequisites Duration not graded guage Project work written and/or verbal academic graded en performance  Oral examination written and/or verbal academic 25 graded en performance  Credits according ECTS 6 LP  Workload 180 h  Duration 1 semester  Frequency winter term  Maximum number of students no limitation  Maximum number of students no limitation	W
obligatory: MA-MOROB-M03 recommended: none  4 Study program allocation  Study program (alternative) mandatory / elective module code code module code module code module code module code code module code semination Standards code code module code	W
MA-MOROB-M03 recommended: none  Study program allocation  Study program (alternative) mandatory / elective recommodule code module code code module code code code code code code code cod	
none  Study program allocation  Study program (alternative) module code module sem module code module sem module code module sem module code module sem module sem module code module sem module sem module sem module code module sem	
Study program (alternative) mandatory / elective recommodule code module code sem MA·MOROB-E12 Elective selection 3rd set MA·M	
Mobile Robotics (M.Sc.)   MA-MOROB-E12   Elective selection   3rd set	
Frequency    Solution   Preserved   Preser	mended ester
Examination(s):  Type	mester
Examination(s):  Type	
Project work written and/or verbal academic performance oral examination written and/or verbal academic performance oral examination written and/or verbal academic performance oral examination oral examination written and/or verbal academic performance oral examination oral exa	
performance   25 graded   en	Weight
Performance  Credits according ECTS 6 LP  Workload 180 h  Duration 1 semester  Frequency winter term  Maximum number of students no limitation	30%
6 LP  7 Workload 180 h  8 Duration 1 semester  9 Frequency winter term  10 Maximum number of students no limitation	70%
7 Workload 180 h  8 Duration 1 semester  9 Frequency winter term  10 Maximum number of students no limitation	
180 h  8 Duration 1 semester  9 Frequency winter term  10 Maximum number of students no limitation	
8 Duration 1 semester 9 Frequency winter term 10 Maximum number of students no limitation	
1 semester  9 Frequency winter term  10 Maximum number of students no limitation	
9 Frequency winter term 10 Maximum number of students no limitation	
winter term  10 Maximum number of students no limitation	
10 Maximum number of students no limitation	
no limitation	
11   Module coordination	

Name	Organization	SWS	exe.	res.
Prof. Dr. Chris McCool	Institut für Landtechnik	2	Χ	Χ
Dr. Michael Halstead	Institut für Landtechnik	2	Χ	
Module coordinator / Organizati Prof. Dr. Chris McCool	on:			
2 Further information				
none				
Date of contract				
3 Date of version				





Coc	le: MA-MOROB	3-E13								
Titl										
1	Content and intended	d learning	outcomes							
	of driving-related e	entities; Pl	ears and current cha D and model-predic E-driving car simulat	tive control fo	r stee	ring a	utonomous	vehicle	es; path	
			lementation of basion							
2	Teaching and learning						<u>,</u>	··		pp
	Туре	Topic			La gua		Group- size	SWS	Work- load	Term
	Lecture	Techniqu	ues for Self-Driving	Cars	е	n	30	2	90	W
	Exercise, scien- tific/practical	Techniqu	ues for Self-Driving	Cars	е	n	15	2	90	W
3	Prerequisites to take	e part the	module							
	obligatory: MA-MOROB-M01									
	recommended: MA-MOROB-M06									
4	Study program alloca	ation								
	Study program			(alternativ module co		, , , , , , , , , , , , , , , , , , ,				mended ester
	Mobile Robotics (M.	.Sc.)		MA-MOROB-E13 Elective selecti		tion				
	Geodetic Engineerin			MGE-MSR-06		Elective selection			3rd se	mester
	Geodäsie und Geoin	nformation	(M.Sc.)	M26		Fachgebundener Wahlpflichtbereich: Wahlpflichtmodul "groß"  3. Fachse ter				
5	Requirements for the	e rewardin	ng of credits (ECTS)							
	Examination(s): Type		Prerequisites			Oura- tion	graded/ not grade		_an- uage	Weight
	Oral examination		written and/or verb performance	al academic		25	graded		en	100%
6	Credits according EC	CTS								
7	Workload									
	180 h									
8	Duration									
	1 semester									
9	Frequency									
	winter term									
10	Maximum number of	students								
	no limitation									
11	Module coordination									

	Lecturer:				
	Name	Organization	SWS	exe.	res.
	PD Dr. Jens Behley	Institut für Geodäsie und Geoinformation	2	Χ	Χ
	Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	2	Χ	
	Module coordinator / Organization: PD Dr. Jens Behley, Prof. Dr. Cyrill Stach	niss (Institut für Geodäsie und Geoinformatic	on)		
12	Further information				
	Lectures and tutorials will take place in pers	on. Video recordings of lectures from past ye	ear(s) aı	re availa	able
13	Date of version				
	26.03.2024 (20262)				





Cod	de: MA-MOROB	-E14										
Title	e: <b>High Precis</b>	ion Sens	ing									
1	Content and intended	d learnin	g outcomes									
	Content:											
	High precision kin influencing factors		nd static laser sca	anning,	, aspects of s	ystem	calibration, a	ccurac	y analys	sis and		
	Qualification goals:											
	Perform high prec accuracy requirem work, critical discu	nents. Ad	vanced knowledge	e, abst								
2	Teaching and learning methods											
	Туре	Topic				Lan-	Group-	SWS	Work	- Ter		
						guage	size		load			
	Exercise, practical		recision Sensing			en	15	3	105	-		
	Seminar	High P	recision Sensing			en	20	1	75	W		
3	Prerequisites to take	part the	module									
	obligatory:											
	none											
	recommended:											
4	MA-MOROB-M02; MA-MOROB-M05											
1	Study program alloc	ation										
	Study program				(alternative) module code		andatory / el module	ective		nmende		
	Mobile Robotics (M.	Sc )			IA-MOROB-E1	-	Elective selec	tion	1	nester emeste		
	-	•								Sid Scilicster		
5	Requirements for the rewarding of credits (ECTS)  Evamination(s):											
	Examination(s):			Dura	ı- graded	,	Lon	\\\a:\a				
	Type		Prerequisites			tion	_		Lan- guage	Weight		
	Project work			or verbal academic		-	graded		en			
			performance									
5	Credits according ECTS											
	6 LP											
7	Workload											
	180 h											
5	Duration											
	1 semester											
	1 semester Frequency											
)	1 semester Frequency winter term	student										
)	1 semester Frequency winter term Maximum number of	student	S									
10	1 semester Frequency winter term	student	5									
10	1 semester Frequency winter term Maximum number of no limitation	student	S									
10	1 semester Frequency winter term Maximum number of no limitation Module coordination	student		Organiz	ation			SW	/S exe	e. re:		
10	1 semester Frequency winter term Maximum number of no limitation Module coordination Lecturer:		0		ation für Geodäsie	und G	eoinformation					
9	1 semester Frequency winter term Maximum number of no limitation Module coordination Lecturer: Name	nlmann	O In	nstitut				1	. X	X		
9 10 11	1 semester  Frequency winter term  Maximum number of no limitation  Module coordination Lecturer: Name Prof. Dr. Heiner Kuh	nlmann peil	O In	nstitut nstitut	für Geodäsie	und G	eoinformation	1 1	. X	Х		

12	Further information
	none
13	Date of version
	26.03.2024 (20262)





Landwirtschaftliche Fakultät Rheinische Friedrich-Wilhelms-Universität Bonn

Code: MA-MOROB-E15
Title: Multi-Agent Learning Systems

#### 1 Content and intended learning outcomes

#### Content

In this course, the students will learn how to model the collective dynamics emerging from multiple independent learning agents. We explore different individual learning processes (e.g., reinforcement learning), the basics of non-cooperative game theory (e.g., social dilemmas), and different settings regarding the observation and policy spaces of these agents (e.g., partial observability). By taking a complex systems science perspective, we will develop a unified approach to these topics. Students learn how to use concepts from non-linear dynamics to distill qualitative insight into the collective behavior of individual learning agents coevolving with dynamic environments and apply these in practical projects.

#### Qualification goals:

Ability to model multi-agent learning systems in Python. Advanced knowledge, abstract thinking, presentation skills, teamwork, critical discussion of methods, interdisciplinary competence

#### 2 Teaching and learning methods

Туре	Topic	Lan- guage	Group- size	SWS	Work- load	Term
Lecture	Multi-agent Learning Systems	en	20	2	90	W
Exercise, scientific/practical	Multi-agent Learning Systems	en	20	2	90	W

#### 3 Prerequisites to take part the module

obligatory:

none

recommended:

Previous programming experience in Python and basic mathematical literacy is a plus.

#### 4 Study program allocation

Study program	(alternative) module code	mandatory / elective module	recommended semester
Mobile Robotics (M.Sc.)	MA-MOROB-E15	Elective selection	3rd semester

#### 5 Requirements for the rewarding of credits (ECTS)

#### Examination(s):

Examination(3).					
Туре	Prerequisites	Dura- tion	graded/ not graded	Lan- guage	Weight
Oral presentation	written and/or verbal academic performance (written report)	15	graded	en	50%
Oral examination	written and/or verbal academic performance (written report)	15	graded	en	50%

#### 6 Credits according ECTS

6 LP

#### Workload

180 h

#### 8 **Duration**

1 semester

#### 9 Frequency

winter term

#### 10 Maximum number of students

no limitation

#### 11 Module coordination

	Lecturer:				
	Name	Organization	SWS	exe.	res.
	Jun.·Prof. Dr. Wolfram Barfuss	Center for Development Research (ZEF)	4	Χ	Χ
	Module coordinator / Organization: JunProf. Dr. Wolfram Barfuss				
12	Further information				
	none				
13	Date of version				
	09.04.2024 (20262)				





Coc	de: MA-MOROB	-E16									
Titl	e: Robot Opera	ating Sys	tems								
1	Content and intended	d learnin	g outcomes								
			navigation stack in Ro A focus will be on m								
		Vork in sr	ecosystem, focusing mall teams realizing								
2	Teaching and learning	g metho	ds								
	Туре	Topic				an. age	Group- size	SWS	Work- load	Term	
	Lecture	Robot (	Operating Systems		е	n	30	1	30	W	
	Exercise, practical	Robot C	Operating Systems		е	en	15	1	60	W	
	recommended:		able C++ programm	ing experienc	e in t	heoret	ical and pra	ctical 1	form		
4	Study program allocation										
	Study program			(alternativ		,			recommended semester		
	Mobile Robotics (M.Sc.)			MA-MOROB	-E16	Ele	ective select	tion	3rd se	mester	
	Geodäsie und Geoin	formatio	n (M.Sc.)	M25		Fachgebundener 3. Fach Wahlpflichtbereich: te Wahlpflichtmodul "Block"					
5	Requirements for the	e rewardi	ng of credits (ECTS)							<u> </u>	
	Examination(s):										
	Туре		Prerequisites			Dura- tion	graded/ not grade		Lan- uage	Weight	
	Project work		written and/or verb performance	al academic		-	graded		en	100%	
6	Credits according EC	:TS									
7	3 LP Workload										
/	90 h										
8	Duration										
	1 semester										
9	Frequency										
	winter term										
10	Maximum number of	students									
1.1	no limitation										
11	Module coordination										

Lecturer:									
Name	Organization	SWS	exe.	res.					
Dr. Tiziano Guadagnino	Institut für Geodäsie und Geoinformation	1	Χ	Χ					
Team Prof. Stachniss	Institut für Geodäsie und Geoinformation	1	Χ						
Module coordinator / Organization: Dr. Tiziano Guadagnino, Prof. Dr. Cy	rill Stachniss (Institut für Geodäsie und Geoinforr	nation)							
12 Further information	Further information								
The course will be executed as a block	module								
* https://docs.ros.org/en/rolling/Relea	ases/Release-Humble-Hawksbill.html								
13 Date of version									
26.03.2024 (20262)									





Coc	le: MA-MOROB	-E17									
Title	e: <b>Explainable</b>	Machine	Learning								
1	Content and intended	d learnin	g outcomes								
	Content:										
	Advanced methods	s of macl	nine learning, explair	nable machine	learr	ning					
	Qualification goals:										
			of machine learning								
	focus on methods of explainable mad		nable machine learn	ing; ability to	desig	n and	implement	a meth	od from	the field	
2	Teaching and learning										
	Туре	Topic			l a	ın-	Group-	SWS	Work-	Term	
		. 56.5				age	size	00	load		
	Lecture	Explain	able Machine Learni	ng	е	n	30	1	30	W	
	Exercise, practical	Explain	able Machine Learni	ng	е	n	15	1	60	W	
3	Prerequisites to take	part the	module								
	obligatory:										
	none										
	recommended:										
	Basic knowledge in	n deep m	achine learning								
4	Study program allocation										
	Study program			(alternativ module co		mar	ndatory / ele module	ective		mended ester	
	Mobile Robotics (M.Sc.)			MA-MOROB	-E17	EI	ective selec	tion	3rd se	mester	
	Geodäsie und Geoinformation (M.Sc.)			M27			achgebunde			semes-	
						Wahlpflichtbereich: Wahlpflichtmodul			t	er	
				, ,	"klein"	Jaur					
5	Requirements for the rewarding of credits (ECTS)										
J	Examination(s):	erewalu	ing of credits (ECTS)								
	Type		Prerequisites		Т	Dura-	graded/		_an-	Weight	
	Type		1 Toroquisites			tion	not grade		uage	Wolgitt	
	Project work		written and/or verb performance	al academic		20	graded		en	100%	
6	Credits according EC	TS									
	3 LP										
7	Workload										
	90 h										
8	Duration										
	1 semester										
9	Frequency										
	winter term										
10	Maximum number of	students	5								
	no limitation										
11	Module coordination										

Name	Organization	SWS	exe.	res.
Prof. Dr. Ribana Roscher	Institut für Geodäsie und Geoinformation	1	Χ	Χ
M.Sc. Ahmed Emam	Institut für Geodäsie und Geoinformation	1	Χ	
·	: ut für Geodäsie und Geoinformation)			
Further information				
Inone				

# Module Manual Master's Program

Mobile Robotics (M.Sc.)

**Master's Thesis** 





Cod	e: <b>MA-MOROB</b>	-MT											
Title	e: Master's Th	esis											
1	Content and intended learning outcomes												
	Content:												
	According to the Master's Thesis task												
	Qualification goals:												
	Independent and extensive analysis and interpretation of a research task; Ability to independently cope with a scientific problem in the relevant subject area on the basis of scientific methods within a set period of time; Specialized professional and conceptual skills to assess and present the research results; Systematic												
	search of information and literature; Understanding and using scientific texts; Writing scientific text in a												
	concise way; Presentation of findings and results.												
2	Teaching and learning methods												
	Туре	Type Topic						Group-	SWS	Work-	Term		
					gua	age	size	0	load				
	Thesis	Master's Thesis				е	en 1			900	S		
3	Prerequisites to take part the module												
	obligatory:												
	all mandatory modules (54 ECTS-CP)												
	recommended:												
	none												
4	Study program allocation												
	Study program				(alternative)		mandatory / elec						
	Mobile Robotics (M.Sc.)			module cod							nester		
				MA-MOROB-M			Γ General mandato selection			ry 4th semester			
												_	
5	Requirements for the rewarding of credits (ECTS)												
	Examination(s):  Type Prerequisites Dura- graded/ Lan-								00	Waight			
	Type		Prerequisites				tion not grade				Weight		
	Master's Thesis		none					graded		en	100%		
6	Credits according EC	ers.										_	
O	30 LP	,,,											
7	Workload											Ī	
	900 h												
8	Duration												
	1 semester												
9	Frequency												
	summer term												
10	Maximum number of students												
	no limitation											_	
11 Module coordination													
	Lecturer:			0					1	. 1			
	Name			Organization					SW		res.		
	All lecturers of the study program									Х	Х		
		Module coordinator / Organization:  Prof. Dr. Cyrill Stockholog (Institut für Coodigie und Coolinformation)											
1.0	Prof. Dr. Cyrill Stachniss (Institut für Geodäsie und Geoinformation)												
12	Further information												

The Master's thesis is issued at the beginning of the fourth semester. The Master thesis task is given by the thesis supervisor over the examination board. According to the examination regulations the working time of the Master thesis is six months; the Master's thesis may be submitted after 4 months at the earliest. Upon motivated request, the examination board, in agreement with the supervisor, may grant an extension of time of up to six weeks. The Master thesis has to be submitted to the examination board. The result of the evaluation of the Master thesis shall be brought to the attention of the student eight weeks after submission at the latest. Parts of the thesis:

- \* Written part of the Master Thesis
- \* Appendix 1: Paper-style summary of four to six pages (recommended: IEEE paper style)
- \* Appendix 2: Poster ("eye-catching presentation", concise presentation with figures and a few words: relevance, procedure, results)
- \* Bibliography
- \* Colloquium

#### 13 Date of version

26.03.2024 (20271)