

# UTN

## M.Sc. Artificial Intelligence and Robotics

**Module Handbook** 

WiSe 24/25 25.09.2024

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### Learning outcomes

**Goal 1**: To provide students theory-grounded and science-based content and methods for the innovative, effective and sustainable design or development of technologies for AI and robotics systems.

- *Objective 1.1:* Students are able to understand advanced fundamental approaches in Artificial intelligence and Robotics including Machine Learning, Computer Vision, and Data Science.
- *Objective 1.2:* Students are able to articulate and differentiate their knowledge from different domains regarding innovative ideas.
- *Objective 1.3:* Students are able to critically reflect on limitations of state-of-theart approaches.

**Goal 2**: To provide students with scientifically-based experience (content, methods, assignments) to develop and apply skills in data collection, analysis and evaluation for AI and robotics systems.

*Objective 2.1:* Students are able to apply state-of-the-art methods to given problems and existing datasets.

*Objective 2.2:* Students are able to scientifically analyze AI approaches.

*Objective 2.3:* Students are able to combine their knowledge from different domains to identify innovative solutions.

**Goal 3**: To provide students with scientific experiences to create novel solutions of AI/robotics technologies in response to current and future challenges of emerging technologies.

*Objective 3.1:* Students are able to create novel AI or robotic systems that extend the state of the art.

*Objective 3.2:* Students are able to evaluate the consequences of the application of AI and robotics approaches on spheres outside their own core expertise and adapt their approaches appropriately.

**Goal 4:** To provide students theory-grounded and science-based content and methods from complementary academic fields in order to critically reflect AI and robotic approaches and their consequences.

- *Objective 4.1:* Students are able to understand fundamental approaches in selected fields of social sciences or humanities.
- *Objective 4.2:* Students are able to combine knowledge from different academic fields to evaluate AI and robotics approaches.

#### Goal 5:

- To provide students with techniques to act effectively also in diverse teams and continuously develop their own expertise and learning.
- To provide students with the capability to demonstrate awareness for sustainability and democratic citizenship.
- To enable students to reflect and relate their own actions to social and ethical contexts.
- *Objective 5.1:* Students are able to appropriately coordinate, cooperate and communicate with the target group.
- *Objective 5.2:* Demonstrate effective problem solving and critical thinking skills in resolving job-related issues.
- *Objective 5.3*: Students are able to utilize adaptive expertise and pursue creativity and lifelong learning.
- *Objective 5.4:* Students are able to demonstrate values of a democratic society as well as sustainable environment and act accordingly.
- *Objective 5.5:* Students are able to reflect on technology leadership and knowledge of ethics and relate them to current and future socio-technical contexts.

## Study program outline

	Module	ECTS	Associated courses
	Artificial Intelligence Basic Module	6	Course Artificial Intelligence
>	Mobile Robot Navigation Basic Module	6	Course Mobile Robot Navigation
mandatory	Machine Learning Basic Module	6	Course Machine Learning
mano	Deep Learning Basic Module	6	Course Deep Learning
	Computer Vision Basic Module	6	Course Computer Vision
	Data Engineering Basic Module	6	Course Data Engineering
	Advanced Module 1	6	All advanced AIR courses Choice of one course per module
ve	Advanced Module 2	6	It is recommended to finish the basic module before starting the advanced
elective	Advanced Module 3	6	<ul> <li>module.</li> <li>examples for advanced course include:</li> <li>Cloud Databases</li> <li>Large Language Models</li> <li>Multimodal Foundation Models</li> <li>3D Vision and Geometry</li> </ul>
mandatory	Learning in Transformation Project	12	Learning in Transformation Project
Ĕ	Key Competencies Basic Module	6	Courses Good Scientific Practice, Project Management, Communication All three courses have to be taken
	Key Competencies Module 1	6	All KC courses For each module course totaling 6 ECTS-
elective	Key Competencies Module 2	6	Points have to be taken (usually two to three courses)
ele	Interdisciplinary Module 1	6	All ID courses Choice of one course per module
	Interdisciplinary Module 2	6	
	Master Thesis	24	Master Thesis and Colloquium

# **Recommended Study Plan**

Semester					
1	Artificial Intelligence (req.)	Mobile Robot Navigation (req.)	Machine Learning (req.)	Data Engineering (req.)	Key Competencies Basic Module
2	Deep Learning (req.)	D <sup>Computer Vision</sup> (req.)	Interdisciplinary Module 1	Key Competencies Module 1	Learning in
3	Advanced Module 1 e.g. Cloud Databases	Advanced Module 2 e.g. Large Language Models	Advanced Module 3 e.g. Multimodal Foundation Models	Interdisciplinary Module 2	Transformation (Project)
4			Key Competencies Module 2		

## **List of Modules**

Artificial Intelli	gence Basic I	Module	6 ECTS		
Recommended Semester	1 <sup>st</sup> semester	Total Workload	180 hours		
Module No.	1-M-AIR	1-M-AIR-AIB-1			
Duration	one sen	nester			
Course Frequency	winter s	winter semester			
Module language	English	English			
Admission requirement	t <b>s</b> None	None			
Associated courses	Artificia	l Intelligence			
Instructor	Prof. Dr	. Wolfram Burgard			
Examination	Learnin	g-oriented assignme	ents		
Grading	graded	graded Students are able to			
Learning outcomes	intel clas and form algo expl logid appl and iden intel intel intel	ligence sify different types intelligent agents nulate problems as s rithms to solve then ain basic concepts o y basic approaches decision making und tify advanced conce ligence ess ethical conseque ligence and its appl rdisciplinary aspects	of first-order and predicate to probabilistic reasoning der uncertainty epts of artificial ences of artificial lication and discuss s of artificial intelligence		
Contents	The con content Norvig, Chapter	The contents of this module are mainly based on the contents of the textbook: Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, Chapter 1-4. The book is available in the library.			
Teaching and learning			2		
Related Programs		I & Robotics			

Mobile Robot N	avigatio	on Basic	Module		6 ECTS		
Recommended	1 <sup>st</sup> semest	er	Total		180 hours		
Semester		Workload					
Module No.		1-M-AIR-MRB-1					
Duration		one semester					
Course Frequency		winter sem	lester				
Module language		English					
Admission requiremen	ts	None					
Associated courses		Mobile Rob	ot Navigation				
Instructor		Prof. Dr. W	olfram Burgard				
Examination		Learning-oriented assignments					
Grading		graded					
Learning outcomes		<ul> <li>and mo</li> <li>compare</li> <li>robot m</li> <li>mappine</li> <li>exploration</li> <li>design</li> <li>navigation</li> <li>identify</li> <li>assession</li> </ul>	basic approache tion models as we re basic approach apping, simultan g, motion and par tion basic architectur e autonomously i advanced conce ethical conseque	ell as les to eous th pla es for in con pts o nces	robot localization, localization and nning, and vehicles that nplex environments		
Contents		<ul> <li>robot lo</li> <li>robot m</li> <li>simulta</li> </ul>	ilistic sensor and ocalization napping neous localizatio and path plannin	n and	mapping		
Teaching and learning	formats	See syllab			•		
Related Programs		M. Sc. Al &					

Recommended Semester         1st semester         Total Workload         180 hours           Module No.         1-M-AIR-MLB-1         1000000000000000000000000000000000000	Machine Learn	ing Basic	Modul	е	6	ECTS
Module No.         1-M-AIR-MLB-1           Duration         one semester           Course Frequency         winter semester           Module language         English           Admission requirements         None           Associated courses         Machine Learning           Instructor         NN           Examination         Learning-oriented assignments           Grading         graded           Learning outcomes         Students are able to           •         explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization           •         compare basic approaches to regression, classification, clustering, and principle componen analysis           •         implement techniques for model selection and regularization           •         develop strategies to solve problems using machine learning approaches           •         identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects           •         supervised Learning (Regression and Classification)           •         unsupervised Learning (Clustering, PCA)	Recommended	1 <sup>st</sup> semester		Total	18	0 hours
Duration         one semester           Course Frequency         winter semester           Module language         English           Admission requirements         None           Associated courses         Machine Learning           Instructor         NN           Examination         Learning-oriented assignments           Grading         graded           Learning outcomes         Students are able to           • explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization           • compare basic approaches to regression, classification, clustering, and principle componen analysis           • implement techniques for model selection and regularization           • develop strategies to solve problems using machine learning approaches           • identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects           Contents         • supervised Learning (Regression and Classification)           • unsupervised Learning (Clustering, PCA)         • weakly-supervised learning	Semester			Workload		
Course Frequency         winter semester           Module language         English           Admission requirements         None           Associated courses         Machine Learning           Instructor         NN           Examination         Learning-oriented assignments           Grading         graded           Learning outcomes         Students are able to           •         explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization           •         compare basic approaches to regression, classification, clustering, and principle componen analysis           •         implement techniques for model selection and regularization           •         develop strategies to solve problems using machine learning approaches           •         identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects           Contents         •           •         supervised Learning (Regression and Classification)           •         unsupervised Learning	Module No.	1-	M-AIR-M	LB-1		
Module language         English           Admission requirements         None           Associated courses         Machine Learning           Instructor         NN           Examination         Learning-oriented assignments           Grading         graded           Learning outcomes         Students are able to           •         explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization           •         compare basic approaches to regression, classification, clustering, and principle componen analysis           •         implement techniques for model selection and regularization           •         develop strategies to solve problems using machine learning approaches           •         identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects           Contents         •           •         supervised Learning (Regression and Classification)           •         unsupervised Learning (Clustering, PCA)	Duration	0	ne semes	ter		
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Associated courses       Machine Learning         Instructor       NN         Examination       Learning-oriented assignments         Grading       graded         Learning outcomes       Students are able to <ul> <li>explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization</li> <li>compare basic approaches to regression, classification, clustering, and principle componen analysis</li> <li>implement techniques for model selection and regularization</li> <li>develop strategies to solve problems using machine learning approaches</li> <li>identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects</li> </ul> <li>Contents</li> <li>supervised Learning (Regression and Classification)</li> <li>unsupervised Learning (Clustering, PCA)</li> <li>weakly-supervised learning</li>	Module language	E	English			
Instructor         NN           Examination         Learning-oriented assignments           Grading         graded           Learning outcomes         Students are able to           • explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization           • compare basic approaches to regression, classification, clustering, and principle componen analysis           • implement techniques for model selection and regularization           • develop strategies to solve problems using machine learning approaches           • identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects           Contents         • supervised Learning (Regression and Classification)           • unsupervised Learning (Clustering, PCA)           • weakly-supervised learning	Admission requirement	nts N	None			
ExaminationLearning-oriented assignmentsGradinggradedLearning outcomesStudents are able to• explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization• compare basic approaches to regression, classification, clustering, and principle componen analysis• implement techniques for model selection and regularization• develop strategies to solve problems using machine learning approaches• identify advanced concepts of machine learning and its application and discuss interdisciplinary aspectsContents• supervised Learning (Regression and Classification) • unsupervised Learning (Clustering, PCA) • weakly-supervised learning	Associated courses	Ν	Machine Learning			
Grading       graded         Learning outcomes       Students are able to         • explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization         • compare basic approaches to regression, classification, clustering, and principle componen analysis         • implement techniques for model selection and regularization         • develop strategies to solve problems using machine learning approaches         • identify advanced concepts of machine learning and its application and discuss interdisciplinary aspects         Contents       • supervised Learning (Regression and Classification)         • unsupervised Learning (Clustering, PCA)         • weakly-supervised learning	Instructor	N	NN			
Learning outcomesStudents are able to• explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization• compare basic approaches to regression, classification, clustering, and principle componen analysis• implement techniques for model selection and regularization• develop strategies to solve problems using machine learning approaches• identify advanced concepts of machine learning and its application and discuss interdisciplinary aspectsContents• supervised Learning (Regression and Classification) • unsupervised Learning (Clustering, PCA) • weakly-supervised learning	Examination	L	earning-o	riented assignm	ents	
<ul> <li>explain basic approaches to supervised, unsupervised, weakly-supervised learning, reinforcement learning, gradient descent and optimization</li> <li>compare basic approaches to regression, classification, clustering, and principle componen analysis</li> <li>implement techniques for model selection and regularization</li> <li>develop strategies to solve problems using machine learning approaches</li> <li>identify advanced concepts of machine learning</li> <li>assess ethical consequences of machine learning and its application and discuss interdisciplinary aspects</li> <li>Contents</li> <li>supervised Learning (Regression and Classification)</li> <li>unsupervised Learning (Clustering, PCA)</li> <li>weakly-supervised learning</li> </ul>	Grading	g	graded			
Classification) <ul> <li>unsupervised Learning (Clustering, PCA)</li> <li>weakly-supervised learning</li> </ul>		•	explain unsupe reinford optimiz compar classifi analysi implem regular develop machin identify assess and its aspects	basic approache rvised, weakly-s cement learning, re basic approach cation, clusterin s ent techniques f ization o strategies to so e learning appro y advanced conce ethical conseque application and es	upervised gradient nes to reg g, and pri or model olve probl aches epts of m ences of r discuss in	l learning, descent and gression, nciple component selection and ems using achine learning nachine learning iterdisciplinary
I ■ model selection and Regularization	Contents	•	<ul> <li>supervised Learning (Regression and Classification)</li> <li>unsupervised Learning (Clustering, PCA)</li> </ul>			
Teaching and learning formats         See syllabus	Teaching and learning	formats S				
Related Programs     M. Sc. Al & Robotics						

Data Engineeri	ng Basid	c Modul	e	6 ECTS		
Recommended	1 <sup>st</sup> semest	ter Total 180 hours				
Semester		Workload				
Module No.		1-M-AIR-DEB-1				
Duration		one semester				
Course Frequency		winter semester				
Module language		English				
Admission requiremer	nts	None				
Associated courses		Data Engir	neering			
Instructor		Prof. Dr. Andreas Kipf				
Examination		Learning-o	priented assignm	ents		
Grading		graded				
Learning outcomes		<ul> <li>explain basic approaches to data engineering and visualization</li> <li>compare basic approaches to data cleaning and integration</li> <li>design basic architectures for data processing systems and data pipelines</li> <li>identify advanced concepts of data engineering</li> <li>assess ethical consequences of large data and its application and discuss interdisciplinary aspects</li> </ul>				
Contents		<ul> <li>Data Engineering Foundations</li> <li>Data Cleaning</li> <li>Data Integration</li> <li>Data Processing Systems</li> <li>Data Pipelines</li> <li>Visualization</li> </ul>				
Teaching and learning	formats	See syllab	us			
Related Programs		M. Sc. Al &	Robotics			

<b>Computer Visio</b>	on Basic Modu	le	6 ECTS		
Recommended	2 <sup>nd</sup> semester	Total	180 hours		
Semester		Workload			
Module No.	1-M-AIR	-CVB-1			
Duration	one sem	nester			
<b>Course Frequency</b>	summer	semester			
Module language	English				
Admission requirement	nts Deep Le	arning Basic Modu	le should be attended in the		
	same se	mester (highly reco	ommended!)		
Associated courses	Comput	Computer Vision			
Instructor	Prof. Dr.	Prof. Dr. Eddy Ilg			
Examination	Learnin	Learning-oriented assignments			
Grading	graded				
Learning outcomes	<ul> <li>expl form</li> <li>desc visio</li> <li>disc disc</li> <li>impl work</li> <li>iden and</li> <li>desi for a</li> </ul>	nation process; cribe the main discip uss the strengths a iplines in 2D compu- ement basic deep l c on images tify advanced conc gn, analyze and eva in object detection ess ethical consequ its application and	earning architectures that epts of computer vision; Iluate their own approach		
Contents	<ul> <li>Image 2D S</li> <li>Motion</li> </ul>	Image Formation			
Teaching and learning					
Related Programs		I & Robotics			
	111. 00. /				

<b>Deep Learning</b>	Basic M	odule		6 ECTS		
Recommended	2 <sup>nd</sup> semes	ter	Total	180 hours		
Semester		Workload				
Module No.		1-M-AIR-RI	_B-1			
Duration		one semes	ter			
Course Frequency		summer se	mester			
Module language		English				
Admission requirement	nts	None				
Associated courses		Deep Learr	ning			
Instructor		Prof. Dr. Jos	sif Grabocka			
Examination		Learning-oriented assignments				
Grading		graded				
Learning outcomes		<ul> <li>network</li> <li>convolu</li> <li>explain aspects</li> <li>analyze of practorized of pr</li></ul>	tand basic found ks, regularization ational networks recurrent recurs of deep learning deep learning a tical applications and related fiel ent techniques f ization for deep advanced conce ethical conseque ication and discu	pproaches in the context s from computer vision, ds or model selection and earning epts of deep learning ences of deep learning and uss interdisciplinary		
Contents		<ul> <li>regular</li> <li>convolu</li> <li>recurre</li> <li>practica</li> </ul>	-	earning vorks		
Teaching and learning	formats	See syllab				
Related Programs		M. Sc. Al &				
			<del>-</del>			

SemesterWorkloadModule No.1-M-AIR-AM1-1Durationone semesterCourse Frequencywinter semesterModule languageEnglishAdmission requirementsNoneAssociated coursesAll advanced AIR courses One course has to be takenInstructorDepending on courseExaminationSee syllabus	Advanced Mod	ule 1			6 ECTS
Module No.       1-M-AIR-AM1-1         Duration       one semester         Course Frequency       winter semester         Module language       English         Admission requirements       None         Associated courses       All advanced AIR courses         One course has to be taken       Instructor         Depending on course       Examination         See syllabus       Grading         Learning outcomes       Students are able to         •       develop in-depth knowledge in selected fields of and robotics         •       develop in-depth knowledge in selected fields of and robotics.         •       develop in-depth knowledge in selected fields of and robotics, natural language processing, computer vision, reinforcement learning, dat a engineering, deep learning, robotics, natural language processing, computer vision, reinforcement learning, and control syster         •       analyze and find solutions to a given problem         •       generate novel solutions and approaches to problems based on a concept or a combination of concepts presented in this course         •       develop proficiency in using state-of-the-art Al ar robotics tools and platforms.         •       effectively reflect upon their knowledge and experiences in an interdisciplinary context, as we as identify connections between different disciplines and apply them in a meaningful way         Contents       In the ad	Recommended	3 <sup>rd</sup> semeste	ər	Total	180 hours
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Learning outcomesStudents are able to• develop in-depth knowledge in selected fields of and robotics• demonstrate an advanced and comprehensive understanding of the fundamental concepts, principles, and theories in AI and robotics, such as machine learning, data engineering, deep learning robotics, natural language processing, computer vision, reinforcement learning, and control system• analyze and find solutions to a given problem• generate novel solutions and approaches to problems based on a concept or a combination of concepts presented in this course• develop proficiency in using state-of-the-art AI and robotics tools and platforms.• effectively reflect upon their knowledge and experiences in an interdisciplinary context, as we as identify connections between different disciplines and apply them in a meaningful wayContentsIn the advanced module, students deepen their knowledge in up to three of the six fields artificial intelligence, robot navigation, deep learning, data engineering, machine learning, and computer vision.					
<ul> <li>develop in-depth knowledge in selected fields of and robotics</li> <li>demonstrate an advanced and comprehensive understanding of the fundamental concepts, principles, and theories in AI and robotics, such as machine learning, data engineering, deep learning, robotics, natural language processing, computer vision, reinforcement learning, and control system</li> <li>analyze and find solutions to a given problem</li> <li>generate novel solutions and approaches to problems based on a concept or a combination of concepts presented in this course</li> <li>develop proficiency in using state-of-the-art AI ar robotics tools and platforms.</li> <li>effectively reflect upon their knowledge and experiences in an interdisciplinary context, as we as identify connections between different disciplines and apply them in a meaningful way</li> <li>Contents</li> </ul>	Grading				
knowledge in up to three of the six fields artificial intelligence, robot navigation, deep learning, data engineering, machine learning, and computer vision.			<ul> <li>develop and rob</li> <li>demons underst principl machin robotics vision, r</li> <li>analyze</li> <li>generat problen concep</li> <li>develop robotics</li> <li>effectiv experie as iden disciplii</li> </ul>	o in-depth know otics strate an advance anding of the for es, and theories e learning, data s, natural langu reinforcement lea and find solution is based on a co ts presented in o proficiency in a s tools and plat yely reflect upon nces in an inter tify connections nes and apply the stools and solution	ced and comprehensive undamental concepts, s in AI and robotics, such as engineering, deep learning, age processing, computer earning, and control systems ons to a given problem as and approaches to oncept or a combination of this course using state-of-the-art AI and forms. In their knowledge and disciplinary context, as well s between different and meaningful way
offerings. The syllabus specifies the course content.	Contents	i e e	knowledge intelligence engineerin Students s offerings.	in up to three o e, robot navigat g, machine learn elect one cours	f the six fields artificial ion, deep learning, data ning, and computer vision. e from the advanced course
Teaching and learning formats         See syllabus	Teaching and learning			•	
Related ProgramsM. Sc. Al & Robotics					

Advanced Mod	ule 2			6 ECTS
Recommended	3 <sup>rd</sup> semester		Total	180 hours
Semester			Workload	
Module No.	1-	M-AIR-A	M2-1	
Duration	or	ne semes	ter	
Course Frequency	w	inter sem	nester	
Module language		nglish		
Admission requirement	nts N	one		
Associated courses			ed AIR courses	
			e has to be take	n
Instructor			on course	
Examination		ee syllab		
Grading		ee syllab		
Learning outcomes Contents	•	develop and rob demons unders princip machin robotic vision, r analyze genera probler concep develop robotic effectiv experie as iden discipli	ootics strate an advant tanding of the f les, and theorie e learning, data s, natural langur reinforcement l e and find solution ns based on a c ts presented in proficiency in s tools and plat vely reflect upon ences in an inter tify connection nes and apply t	using state-of-the-art AI and forms. n their knowledge and rdisciplinary context, as well s between different hem in a meaningful way
Contents	kr in er S <sup>-</sup> of	nowledge Itelligenc ngineerin tudents s fferings.	e in up to three o e, robot naviga g, machine lear elect one cours	tudents deepen their of the six fields artificial tion, deep learning, data ning, and computer vision. se from the advanced course course content.
Teaching and learning		ee syllab		
		I. Sc. AI &		

OurationoCourse FrequencywModule languageEAdmission requirementsNAssociated coursesAOOInstructorDExaminationSGradingS	-M-AIR-AN one semest vinter sem English None All advance One course Depending See syllabu See syllabu	ter hester ed AIR courses has to be taken on course	180 hours
Module No.       1-         Duration       0         Dourse Frequency       w         Module language       E         Admission requirements       N         Associated courses       A         Onstructor       D         Examination       S         Arading       S         •       •	one semest vinter sem English None All advance One course Depending See syllabu See syllabu	M3-1 ter ester ed AIR courses e has to be taken on course	
OurationoCourse FrequencywModule languageEAdmission requirementsNAssociated coursesAOOInstructorDExaminationSAradingSearning outcomesS	one semest vinter sem English None All advance One course Depending See syllabu See syllabu	ter hester ed AIR courses has to be taken on course	
Course FrequencywModule languageEAdmission requirementsNAssociated coursesAOOInstructorDExaminationSAradingS••	vinter sem English None All advance One course Depending See syllabu See syllabu	ed AIR courses e has to be taken on course	
Module languageEAdmission requirementsNAssociated coursesAOOInstructorDExaminationSAradingS.earning outcomesS	English None All advance Dne course Depending See syllabu See syllabu	ed AIR courses e has to be taken on course	
Admission requirementsNAssociated coursesAOOInstructorDExaminationSAradingSearning outcomesS	None All advance Dne course Depending See syllabu See syllabu	e has to be taken on course	
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Onstructor     D       Examination     S       Arading     S       .earning outcomes     S	Dne course Depending See syllabu See syllabu	e has to be taken on course	
nstructor D Examination S Grading S earning outcomes S •	Depending See syllabu See syllabu	on course	
Examination S Arading S earning outcomes S •	See syllabı See syllabı		
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earning outcomes S	-		
•			
• • •	and rob demons underst principl machine robotics vision, r analyze generat problen concep develop robotics effectiv experie as ident	o in-depth knowled potics strate an advanced tanding of the fund les, and theories in e learning, data er s, natural languag reinforcement lear e and find solutions te novel solutions ts presented in this o proficiency in usi s tools and platfor vely reflect upon the ences in an interdis tify connections be nes and apply the	ing state-of-the-art AI and ms. heir knowledge and sciplinary context, as well etween different m in a meaningful way
k ir e S o	knowledge ntelligence engineering Students s offerings.	in up to three of t e, robot navigatior g, machine learnin	dents deepen their he six fields artificial n, deep learning, data ng, and computer vision. rom the advanced course
	-	-	
Related Programs	See syllabı		

Learning in Tra	Insforma	ation Project		12 ECTS	
Recommended	2 <sup>nd</sup> and 3 <sup>rd</sup>	Total		360 hours	
Semester	semester	Workload			
Module No.		1-M-AIR-LTP-1			
Duration		two semesters			
Course Frequency		summer semester			
Module language		English			
Admission requireme	nts	None			
Associated courses		Transformative Learr	ing Project	t	
Instructor		1-2 professor(s) from			
		supervise the project	S		
		+ Coaches/Teaching	Assistants		
Examination		Project or scientific p	aper or pre	esentation	
Grading		Pass/fail (with 70% o			
Learning outcomes		Students are able to			
		<ul> <li>identify steps to s</li> </ul>	olving a re	al-world research	
		problem and desig	gn an actio	n plan to implement	
		these steps.			
		<ul> <li>develop and test a</li> </ul>	a working p	prototype.	
		<ul> <li>critically evaluate</li> </ul>	and provid	le feedback on	
		solution approach	es of other	r student groups.	
		• explain and present the solution approach to the			
		stakeholder(s) and peers.			
		<ul> <li>assess/evaluate t</li> </ul>	he outcom	e of the project and	
		defend the develo	pment ste	ps.	
Contents		The Learning in Trans	formation	project is an	
		interdisciplinary scie	ntific resea	irch project that	
		focuses on practical	earning ex	periences. The project	
		aims to provide stude	nts with a	scientific-based	
		approach to solving r	eal-world ii	ndustrial, societal, or	
		political problems fac	ed by non-	university	
		stakeholders. The pro	ject encou	rages students to	
		creatively apply their prior knowledge to solve these			
		problems in groups.			
		For further information see syllabus.			
Teaching and learning	g formats	The module is set up as a mixture of learning units,			
		discussion and supervision sessions, field trips and a			
		high proportion of independent work within student			
		groups. Over the cour			
		milestones help to structure the project planning and			
		assure that the group is on track and on time. They are			
		further used to document the project and learning			
		progress.			
		For further information see syllabus.			
<b>Related Programs</b>		See module description			

Interdisciplina	ry Module 1		6 ECTS		
Recommended	2 <sup>nd</sup> semester	Total	180 hours		
Semester		Workload			
Module No.	2-M-IND	D-IM1-1			
Duration	one sem	nester			
Course Frequency	summer	semester			
Module language	English				
Admission requireme	nts None				
Associated courses		disciplinary courses			
		irse has to be taken			
Instructor		ing on course			
Examination	See syll	abus			
Grading Learning outcomes	graded	ts are able to			
	meth deve and appl theo tech anal impl liber com arts tech	<ul> <li>methods in the social sciences and humanities.</li> <li>develop critical thinking and problem-solving sl and apply them to real-world problems.</li> <li>apply knowledge of social science and liberal at theories to analyze and evaluate the impact of technology on society.</li> <li>analyze the social, ethical, legal, and cultural implications of technology using social science liberal arts methodologies.</li> <li>combine technological, social science, and liber arts knowledge and methods to create novel technological solutions.</li> </ul>			
Contents	interdise scientifi from the offered ethics/p studies.	In the interdisciplinary module, students develop an interdisciplinary perspective that complements their scientific core courses. Students select one course from the interdisciplinary course offerings. Courses ar offered in the area of design, social sciences, ethics/philosophy, law, and economics/business studies. The syllabus specifies the course content.			
Teaching and learning					
Related Programs		I & Robotics			

Interdisciplinary Module 2 6 ECTS					
Recommended	4 <sup>th</sup> semester	Total	180 hours		
Semester		Workload			
Module No.	2-M-IND	-IM2-1			
Duration	one sem	ester			
Course Frequency	summer	semester			
Module language	English				
Admission requiremen	ts None				
Associated courses	All intere	disciplinary course	s		
	One cou	rse has to be taken	1		
Instructor		ng on course			
Examination	See sylla	abus			
Grading	graded				
Learning outcomes	meth deve solvin probl apply theory techn analy impli libera comb arts l techn	• understand selected scientific approaches and methods in the social sciences and humanities.			
Contents	interdisc scientific from the offered i ethics/pl studies.	In the interdisciplinary module, students acquire an interdisciplinary perspective that complements their scientific core courses. Students select one course from the interdisciplinary course offerings. Courses ar offered in the area of design, social sciences, ethics/philosophy, law, and economics/business studies. The syllabus specifies the course content.			
Teaching and learning		-			

Key Competen	cies Bas	sic Modu	ıle	6 ECTS			
Recommended	1 <sup>st</sup> semest	er	Total	180 hours			
Semester			Workload				
Module No.		8-M-KCO-I	KCB-1				
Duration		one semes	ter				
Course Frequency		winter sem	nester				
Module language		English					
Admission requirement	nts	None					
Associated courses		Good Scier	ntific Practice				
		Project Ma	nagement				
		Communic	_				
		All three co	ourses have to b	e completed			
Instructor		Depending	on course				
Examination			riented assignm	ents			
Grading		pass/fail	<u> </u>				
Learning outcomes		Students a	re able to				
		• underst	tand basic princi	ples of good scientific			
		practic	-				
		<ul> <li>identify</li> </ul>	/ different forms	and situations of scientific			
		miscon	duct and apply s	trategies to avoid them.			
		<ul> <li>discuss</li> </ul>	various project	management techniques			
		and tools.					
		identify potential problems within teams and					
		respond appropriately.					
				understand communication forms and techniques			
		and apply them appropriately to different					
		situations.					
		apply principles of intercultural communication.					
	<ul> <li>commu</li> </ul>	nicate effective	ly in groups with different				
	scienti	fic or profession	al backgrounds.				
Contents	Good Scier	ntific Practice					
		Students learn the rules and values of responsible and					
		ethical research. This includes handling data, sources,					
		and ideas of others, citation rules, forms of scientific					
	misconduct and how to avoid them, and research						
	ethics.						
	Project Management						
	Students learn basic project management tools and						
	techniques and how to apply them correctly. This						
				includes project planning, risk management, roles and			
	associated tasks, team management, project						
				monitoring and evaluation.			
	The course specifically prepares students for the						
				Learning in Transformation Project.			
		Communication					
		Communic	ลแบบ				

	Students acquire communication techniques to communicate effectively in intercultural and interprofessional teams. The course specifically prepares students for the Learning in Transformation Project.
Teaching and learning formats	Courses are offered in weekly sessions or as block
	courses during the course-free period.
	The syllabus specifies the course content.
Related Programs	M. Sc. AI & Robotics

Key Competencies Module 16 ECTS					
Recommended	2 <sup>nd</sup> semes	ter	Total	180 hours	
Semester		1	Workload		
Module No.		8-M-KCO-	KC1-1		
Duration		one semes	ter		
Course Frequency		summer se	emester		
Module language		English			
Admission requiremen	ts	None			
Associated courses		All KC cou	rses		
		Courses to	taling 6 ECTS ha	ve to be taken	
Instructor		Depending	on course		
Examination		See syllab	us		
Grading		pass/fail			
Learning outcomes	<ul> <li>Students are able to</li> <li>apply key techniques and methodologies needed to work in an academic and professional environment.</li> <li>communicate effectively in foreign languages.</li> <li>reflect on and extend their knowledge independently.</li> </ul>				
Contents		In the Key Competencies Module, students acquire academic and professional key competencies. Students select two to three courses from the key competencies course offerings. The syllabus specifies the course content.			
Teaching and learning formatsCourses are offered courses during the The syllabus spec			e offered in weel ring the course-	ly sessions or as k ree period.	olock
<b>Related Programs</b>	M. Sc. AI & Robotics				

Key Competencies Module 26 ECTS					
Recommended	3 <sup>rd</sup> semes			180 hours	
Semester		I	Workload		
Module No.		8-M-KCO-	KC2-1		
Duration		one semes	ter		
Course Frequency		winter sem	nester		
Module language		English			
Admission requiremen	its	None			
Associated courses		All KC cou	rses		
		Courses to	taling 6 ECTS ha	ve to be taken	
Instructor		Depending	on course		
Examination		See syllab	us		
Grading	pass/fail				
Learning outcomes       Students are able to         • apply key techniques and methodologies n         work in an academic and professional envir         • communicate effectively in foreign language         • reflect on and extend their knowledge independently.			d professional environment. y in foreign languages.		
Contents		In the Key Competencies Module, students acquire academic and professional key competencies. Students select two to three courses from the key competencies course offerings. The syllabus specifies the course content.			
cou			Courses are offered in weekly sessions or as block courses during the course-free period. The syllabus specifies the course content.		
<b>Related Programs</b>	M. Sc. AI & Robotics				

Recommended Semester         4 <sup>th</sup> semester         Total Workload         720 hours           Module No.         1-M-AIR-THE-1             Duration         one semester          Course Frequency         winter semester           Module language         English          Admission requirements         None           Associated courses         Master colloquium           Admission requirements         XX           Examination         Thesis and oral exam               Grading         graded                 Learning outcomes         Students are able to	Master Thesis					24 ECTS
Module No.       1-M-AIR-THE-1         Duration       one semester         Course Frequency       winter semester         Module language       English         Admission requirements       None         Associated courses       Master colloquium         Instructor       XX         Examination       Thesis and oral exam         Grading       graded         Learning outcomes       Students are able to         • formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy         • use scientific methods to propose an innovative solution to a complex problem         • critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context         • integrate knowledge from different domains in order to create novel solutions to the research problem         • independently plan a research project within a given time frame         • apply the rules of good scientific practice to all parts of the research project         • structure and communicate research results in accordance with academic standards         Contents       The students select their research topics in coordination with their advisor.		4 <sup>th</sup> semest				720 hours
Durationone semesterCourse Frequencywinter semesterModule languageEnglishAdmission requirementsNoneAssociated coursesMaster colloquiumInstructorXXExaminationThesis and oral examGradinggradedLearning outcomesStudents are able to•formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy•use scientific methods to propose an innovative solution to a complex problem•critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context•integrate knowledge from different domains in 		1	1-M-AIR-TH			
Course Frequencywinter semesterModule languageEnglishAdmission requirementsNoneAssociated coursesMaster colloquiumInstructorXXExaminationThesis and oral examGradinggradedLearning outcomesStudents are able to• formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy• use scientific methods to propose an innovative solution to a complex problem• critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context • integrate knowledge from different domains in order to create novel solutions to the research problem• independently plan a research project within a given time frame • apply the rules of good scientific practice to all parts of the research project• Structure and communicate research results in accordance with academic standardsContentsThe students select their research topics in coordination with their advisor.						
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InstructorXXExaminationThesis and oral examGradinggradedLearning outcomesStudents are able to• formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy• use scientific methods to propose an innovative solution to a complex problem• critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context• independently plan a research project within a given time frame• apply the rules of good scientific practice to all parts of the research project• structure and communicate research results in accordance with academic standardsContentsThe students select their research topics in coordination with their advisor.	•			loquium		
ExaminationThesis and oral exam gradedGradinggradedLearning outcomesStudents are able to• formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy• use scientific methods to propose an innovative solution to a complex problem• critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context• integrate knowledge from different domains in order to create novel solutions to the research problem• independently plan a research project within a given time frame• apply the rules of good scientific practice to all parts of the research project• structure and communicate research results in accordance with academic standardsContentsThe students select their research topics in coordination with their advisor.						
GradinggradedLearning outcomesStudents are able to• formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy• use scientific methods to propose an innovative solution to a complex problem• critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context• integrate knowledge from different domains in order to create novel solutions to the research problem• independently plan a research project within a given time frame• apply the rules of good scientific practice to all parts of the research project• Structure and communicate research results in accordance with academic standardsContentsThe students select their research topics in coordination with their advisor.				oral exam		
Learning outcomesStudents are able to• formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy• use scientific methods to propose an innovative solution to a complex problem• critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context• integrate knowledge from different domains in order to create novel solutions to the research problem• independently plan a research project within a given time frame • apply the rules of good scientific practice to all parts of the research project• Structure and communicate research results in accordance with academic standardsContents						
coordination with their advisor.			<ul> <li>Students are able to</li> <li>formulate a research question in artificial intelligence and robotics, select the appropriate methodology and literature, and design an evaluation strategy</li> <li>use scientific methods to propose an innovative solution to a complex problem</li> <li>critically analyze and evaluate theories and approaches and reflect on their assumptions and limitations also in an interdisciplinary context</li> <li>integrate knowledge from different domains in order to create novel solutions to the research problem</li> <li>independently plan a research project within a given time frame</li> <li>apply the rules of good scientific practice to all parts of the research project</li> <li>structure and communicate research results in</li> </ul>			
colloquium, a separate course that takes place durin the term.	Contents		coordination with their advisor. The students present their work during a research colloquium, a separate course that takes place during			
Teaching and learning formatsIndependent research and colloquium (see syllabus)	Teaching and learning	g formats		nt research and	l colloai	uium (see svllabus)
Related ProgramsM. Sc. AI & Robotics		,				