

Lecture

Fundamentals of Reinforcement Learning

SS 2025

Institut für Nachrichtentechnik

Fachgebiet Kommunikationstechnik

Prof. Dr.-Ing. Anja Klein

Dr. Sabrina Klos & Dr. Andrea Ortiz

About this lecture

The Communications Engineering Lab in the Institut für Nachrichtentechnik
offers the

Lecture

„Fundamentals of Reinforcement Learning“

Prof. Dr.-Ing. Anja Klein

Dr. Sabrina Klos & Dr. Andrea Ortiz

This lecture is an optional course in the following study programs:

MSc etit, MSc iCE, BSc/MSc iST, MSc MEC,...

- In the summer semester 2025, this course is offered in an **inverted classroom** format with discussion sessions **in presence**.
- All course material will be provided via **Moodle**.
- Announcements will also be made via **Moodle** and will be forwarded to the e-mail address you provided in your Moodle account. Please make sure that you receive e-mails sent to this address.

- The lecture topics will be explained in **lecture recordings** by the lecturers.
- Every week a **discussion session in presence** is offered for questions concerning the lecture. Attendance is recommended. **Please check the course calendar for the dates of the discussion sessions and covered lecture content!**
- The videos **are already uploaded** in Moodle.

- Exercises are divided into 1. Theory exercises (S306/053) and 2. Programming exercises (S321/1 PC Pool)
- Exercises take place **weekly** in presence.
- An overview of all exercise dates is given in the **course calendar**. In order to take maximum advantage of the live exercise classes, you should follow this schedule. Please try to solve the task sheet before the respective exercise class takes place.
- The **solutions** are provided after the session took place.

Programming Exercises

- The programming exercise will be in person in the PC Pool S321 1, where you will solve the programming tasks.
- You can solve the tasks using your **own laptop** or **the computers in the PC Pool**.
- You can use **Python** or **MATLAB** as programming language to solve the programming tasks. We recommend to use Python if you are not sure.
- **If you want to use a PC in the PC Pool**, request an account at least **one week before** the first programming exercise on 13.05.2025.

Course Calendar (1/2)

Also available in Moodle and will be updated there if needed



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DARMSTADT

	Special Sessions
	Video Lectures
	Theory Exercise Session
	Programming Exercise Session

	April																					
											Week 1					Week 2						
	07/04/2025	08/04/2025	09/04/2025	10/04/2025	11/04/2025	14/04/2025	15/04/2025	16/04/2025	17/04/2025	18/04/2025	21/04/2025	22/04/2025	23/04/2025	24/04/2025	25/04/2025	28/04/2025	29/04/2025	30/04/2025	01/05/2025	02/05/2025		
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F		
											Chapter 1 - Introduction					Chapter 2 - Probability Theory I Chapter 3 - Probability Theory II						
09:50-11:30												Kick-off session					Video Lecture					
11:40-13:20													Video Lecture					Video Lecture				

	May																								
	Week 3					Week 4					Week 5					Week 6									
	05/05/2025	06/05/2025	07/05/2025	08/05/2025	09/05/2025	12/05/2025	13/05/2025	14/05/2025	15/05/2025	16/05/2025	19/05/2025	20/05/2025	21/05/2025	22/05/2025	23/05/2025	26/05/2025	27/05/2025	28/05/2025	29/05/2025	30/05/2025					
	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F					
	Chapter 4 - Introduction to MABs					Chapter 5 - Stochastic MABs					Chapter 6 - Contextual MABs					Chapter 7 - MDPs									
09:50-11:30		Theory Exercise 1					Progr. Exercise 1					Theory Exercise 2					Progr. Exercise 2								
11:40-13:20			Video Lecture					Video Lecture					Video Lecture					Video Lecture							

Course Calendar (2/2)

Also available in Moodle and will be updated there if needed

		June																			
		Week 7					Week 8					Week 9					Week 10				
		02/06/2025	03/06/2025	04/06/2025	05/06/2025	06/06/2025	09/06/2025	10/06/2025	11/06/2025	12/06/2025	13/06/2025	16/06/2025	17/06/2025	18/06/2025	19/06/2025	20/06/2025	23/06/2025	24/06/2025	25/06/2025	26/06/2025	27/06/2025
		M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F
		Chapter 8 - Dynamic Programing					Chapter 9 - Temp. Difference Learning					Chapter 10 - Function Approximation					Chapter 11 - Policy Gradient				
09:50-11:30			Theory Exercise 3					Progr. Exercise 3					Theory Exercise 4					Progr. Exercise 4			
11:40-13:20				Video Lecture					Video Lecture					Video Lecture					Video Lecture		

		July																			
		Week 11					Week 12					Week 13					Week 14				
		30/06/2025	01/07/2025	02/07/2025	03/07/2025	04/07/2025	07/07/2025	08/07/2025	09/07/2025	10/07/2025	11/07/2025	14/07/2025	15/07/2025	16/07/2025	17/07/2025	18/07/2025	21/07/2025	22/07/2025	23/07/2025	24/07/2025	25/07/2025
		M	T	W	T	F	M	T	W	T	F	M	T	W	T	F	M	T	W	T	F
		Chapter 12 - Actor Critic					Chapter 13 - Use Case					Chapter 14 - Beyond Fundamentals									
09:50-11:30			Theory Exercise 5					Progr. Exercise 5					Theory Exercise 6					Progr. Exercise 6			
11:40-13:20				Video Lecture					Video Lecture					Video Lecture					Exam Consult. Hour		

- Exercises consist of **theoretical** and **programming** tasks.
- Some tasks require participation in Moodle („**Moodle Discussion**“).
- Programming tasks can be solved in Matlab or Python – please use a language you are familiar with.
- As the syntax of both languages is similar, solutions will be **only** explained using **Python**.
- The content of **all** exercises, including the programming tasks, is **relevant for the exam**.

- **The exam is a written exam, closed book, with a duration of 60 minutes. The only aid allowed is a non-programmable pocket calculator.**
- The exam consists of two parts. The first part are short questions that make up roughly 1/3 of the points. The remaining 2/3s of the exam are longer tasks.
- Questions regarding programming or algorithms should be answered with words / in pseudocode. You do not need to use any MATLAB / Python commands.
- We will have a consultation hour for the preparation of the exam where you can bring your questions.
- An example of a previous exam will be provided during the semester

Some additional remarks...

- We encourage you to also use the **Moodle forum** to discuss questions regarding the content.
- We encourage you to **ask questions any time** during our sessions.
- **Anonymous Feedback** about this course (see Moodle) is always welcome.

Lecturer (1st Half of Course)



Dr. rer. nat. Sabrina Klos

s.klos@nt.tu-darmstadt.de

- Since 2022: Senior Data Scientist for Cloud Infrastructure Optimization at SAP
- Since 2021: Lecturer for FoRL at TU Darmstadt
- 2019 – 2021: Post-Doc in the Communications Engineering Lab
- 2014 – 2019: PhD in Electrical Engineering, TU Darmstadt
Dissertation: Context-Aware Decision Making in Wireless Networks: Optimization and Machine Learning Approaches
- 2012 / 2014 B.Sc. / M.Sc. in Mathematics, TU Darmstadt

Research Interests:

- Optimization & Machine Learning, especially Multi-armed Bandits
- Applications in Wireless Networks, e.g., Caching at the Edge, Computation Offloading, Mobile Crowdsourcing
- Applications in Cloud Infrastructure Optimization

Lecturer (2nd Half of Course)



Dr.-Ing. Andrea Ortiz

a.ortiz@nt.tu-darmstadt.de

S3|10 313

- Since 2024: Assistant Professor at TU Wien
- Post-Doc in the Communications Engineering Lab
- PhD in Electrical Engineering, TU Darmstadt
- **Dissertation:** Optimization and Learning Approaches for Energy Harvesting Wireless Communication Systems
- B.Sc. / M.Sc. Electrical Engineering UniNorte – Colombia /TU Darmstadt

Research Interests:

- Optimization & Machine Learning, especially full reinforcement learning problems
- Applications in Wireless Networks, e.g., energy harvesting, resource allocation and performance guarantee provisioning under uncertainty

The Communications Engineering Laboratory

Chair: Prof. Dr.-Ing. Anja Klein

Institut für Nachrichtentechnik

<https://www.kt.tu-darmstadt.de>



Prof. Dr.-Ing. Anja Klein



Loba Fischer



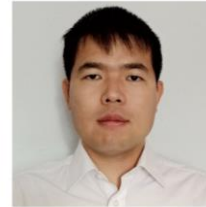
Hauke Fath



Dr. rer. nat. Sabrina Klos née Müller



Dr.-Ing. Andrea Ortiz



Dr.-Ing. Lin Xiang



M. Sc. Sumedh Dongare



M. Sc. Yi Wang



M. Sc. Maximilian Wirth



M. Sc. Bernd Simon



M. Sc. Burak Yilmaz

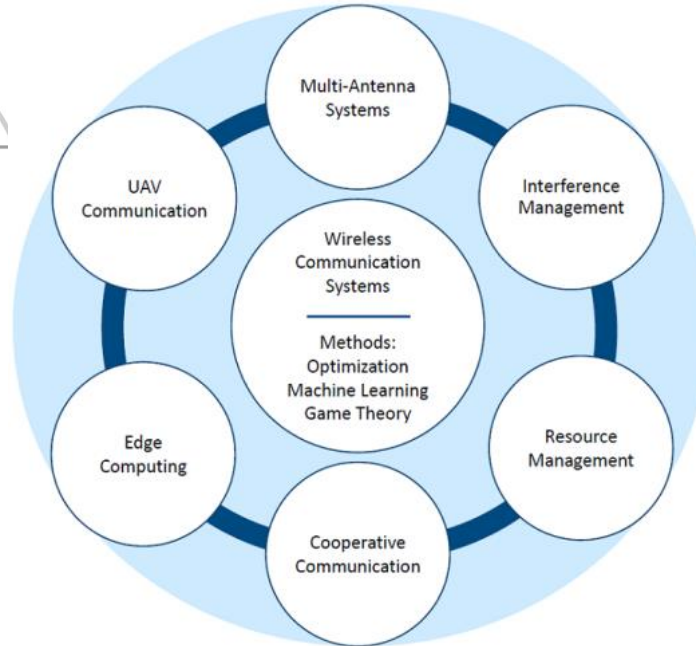


M. Sc. Wanja de Sombre

Further Courses at Master level offered by the Communications Engineering Laboratory

- Lecture **Communication Technology 2**
- Lecture **Mobile Communications**
- Project Seminar **Wireless Communications**
- Master Thesis

Research in the Communications Engineering Laboratory



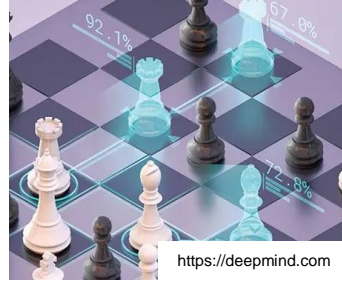
We continuously offer HiWi Jobs, please feel free to ask.

This Lecture in 1 Minute

RL is a computational approach to learning from interaction



Manufacturing



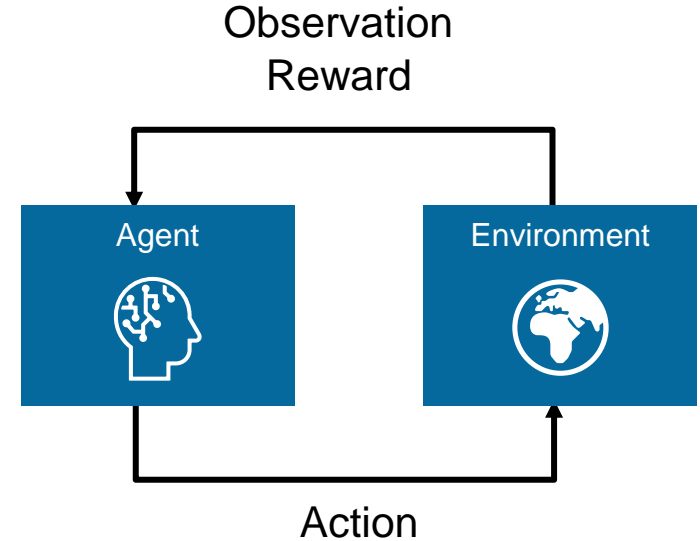
Chess playing



Music recommendation



Navigating in Mars



Recommended Textbooks

Reinforcement Learning and Multi-Armed Bandits

- Richard S. Sutton and Andrew G. Barto, “Reinforcement Learning: An Introduction”, A Bradford Book, Cambridge, MA, USA, 2018.
- Aleksandrs Slivkins, "Introduction to Multi-Armed Bandits", Foundations and Trends in Machine Learning, Vol. 12: No. 1-2, 2019.

Probability Theory and Statistics

- Larry Wassermann, “All of Statistics – A Concise Course in Statistical Inference”, Springer Texts in Statistics, Springer, 2004.
- Scott L. Miller and Donald Childers, “Probability and Random Processes – With Applications to Signal Processing and Communications, Elsevier Academic Press, 2004.
- Judith Eckle-Kohler, Michael Kohler, “Eine Einführung in die Statistik und ihre Anwendungen”, 2. Auflage, Springer, 2011.

Recommended Further Material

Major parts of this lecture are based on the course

Reinforcement Learning

by David Silver, University College London.

Silver's lecture slides and videos are available at:

<https://www.davidsilver.uk/>

<https://www.youtube.com/watch?v=2pWv7GOvuf0>

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Any Questions?



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