







# Lukas Schäfer

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## RESEARCH FOCUS

How can multiple agents learn robust behaviour which transfers to unseen tasks from limited data? Guided by this question, my research focuses on **efficient** and **generalisable decision making** in complex environments, with a particular focus on **reinforcement learning** and **multi-agent systems** in which multiple autonomous agents interact with each other.

Keywords: **reinforcement learning**, **multi-agent systems**, **generalisation**, **exploration**, **imitation learning**

## EDUCATION

### PhD Data Science & Artificial Intelligence

12/2019 - Expected 08/2024

UNIVERSITY OF EDINBURGH

EDINBURGH, UNITED KINGDOM

- › Supervisors: **Stefano V. Albrecht** (primary) and **Amos Storkey** (secondary)
- › Project: **Sample Efficiency and Generalisation in Multi-Agent Reinforcement Learning**
- › Receiving **Principal's Career Development Scholarship** from the University of Edinburgh
- › Organisation and hosting of **RL reading group** with speakers from industry (DeepMind, MSR, Google Brain, FAIR) and academia (Oxford University, McGill University, Georgia Institute of Technology, National University of Singapore)

### M.Sc. Informatics

09/2018 - 08/2019

UNIVERSITY OF EDINBURGH - GRADE: Distinction (77.28%)

EDINBURGH, UNITED KINGDOM

- › Thesis: **Curiosity in Multi-Agent Reinforcement Learning** (74%), advised by Stefano V. Albrecht
- › Received **DAAD graduate scholarship** and **Stevenson Exchange Scholarship**

### B.Sc. Computer Science, minor subject Japanese

10/2015 - 09/2018

SAARLAND UNIVERSITY - GRADE: 1.2 (GERMAN SCALE) WITHIN TOP 5%

SAARBRÜCKEN, GERMANY

- › Thesis: **Domain-Dependent Policy Learning using Neural Networks in Classical Planning** (1.0), advised by Jörg Hoffmann

## EXPERIENCE

### Textbook Author

03/2022 - 10/2023

Designed and wrote a **textbook on multi-agent reinforcement learning** with **Stefano V. Albrecht** and **Filippos Christianos** (equal contributions). The book will be published with **MIT Press** in 2024 [1].

### Research Scientist Intern

04/2023 - 06/2023

MICROSOFT RESEARCH

CAMBRIDGE, UNITED KINGDOM

- › Conducted an empirical study on the effectiveness of various **visual encoders**, including pre-trained **vision foundation models**, for **imitation learning in modern video games** [11]
- › Developed **novel platform** for imitation learning in Minecraft Dungeons **from scratch**, including human gameplay recorder, imitation learning framework using **PyTorch Lightning**, and programmatic interface for online evaluation
- › Mentored by **Sam Devlin** and **Tabish Rashid**

### Young Research Attendee

09/2022 - 09/2022

HEIDELBERG LAUREATE FORUM

HEIDELBERG, GERMANY

- › Selected as one of 100 international young researchers in computer science to network and discuss research

### Research Scientist Intern

07/2022 - 12/2022

HUAWEI NOAH'S ARK LAB

LONDON, UNITED KINGDOM

- › Researched the application of **ensemble models** to guide exploration and improve training stability of **multi-agent reinforcement learning** under the supervision of **David Mguni** [8]

### Research Intern

11/2020 - 03/2021

DEMATIC - TECHNOLOGY AND INNOVATION

REMOTE

- › Applied multi-agent reinforcement learning to automate **large-scale robotic warehouse logistics** [12]
- › My internship led to two further internship projects and a **fellowship-funded research collaboration**

## SKILLS

### Machine Learning & Data Science

Python: PyTorch • PyTorch Lightning • NumPy • Pandas • Scikit-Learn • Matplotlib • Jupyter • Anaconda

### Software Engineering

C++ • C • Bash • Git • Docker • HTML • CSS • JavaScript

### Natural Languages

German (native) • English (fluent) • Chinese (beginner)

### Soft Skills

Teamwork • Teaching • Communication • Organisation

## SELECTED PUBLICATIONS

### Textbook

- [1] S. V. Albrecht, F. Christianos, and **Lukas Schäfer** (equal contributions), *Multi-Agent Reinforcement Learning: Foundations and Modern Approaches*. To be published with **MIT press**, 2024.

### Conferences and Journals

- [2] T. McInroe, **Lukas Schäfer**, and S. V. Albrecht, “Learning representations for control with hierarchical forward models,” *TMLR*, 2023.
- [3] **Lukas Schäfer**, F. Christianos, J. P. Hanna, and S. V. Albrecht, “Decoupled reinforcement learning to stabilise intrinsically-motivated exploration,” in *AAMAS*, 2022.
- [4] **Lukas Schäfer**, “Task generalisation in multi-agent reinforcement learning,” in *AAMAS, Doctoral Consortium*, 2022.
- [5] R. Zhong, D. Zhang, **Lukas Schäfer**, S. V. Albrecht, and J. P. Hanna, “Robust on-policy data collection for data efficient policy evaluation,” in *NeurIPS*, 2022.
- [6] G. Papoudakis, F. Christianos, **Lukas Schäfer**, and S. V. Albrecht, “Benchmarking multi-agent deep reinforcement learning algorithms in cooperative tasks,” in *NeurIPS, Datasets and Benchmarks Track*, 2021.
- [7] F. Christianos, **Lukas Schäfer**, and S. V. Albrecht, “Shared experience actor-critic for multi-agent reinforcement learning,” in *NeurIPS*, 2020.

### Workshops

- [8] **Lukas Schäfer**, O. Slumbers, S. McAleer, Y. Du, S. V. Albrecht, and D. Mguni, “Ensemble value functions for efficient exploration in multi-agent reinforcement learning,” in *Adaptive and Learning Agents Workshop at AAMAS*, 2023.
- [9] **Lukas Schäfer**, F. Christianos, A. Storkey, and S. V. Albrecht, “Learning task embeddings for teamwork adaptation in multi-agent reinforcement learning,” in *Generalization in Planning Workshop at NeurIPS*, 2023.
- [10] A. Andres, **Schäfer, Lukas**, E. Villar-Rodriguez, S. V. Albrecht, and J. Del Ser, “Using offline data to speed-up reinforcement learning in procedurally generated environments,” in *Adaptive and Learning Agents Workshop at AAMAS*, 2023.

### Pre-prints

- [11] **Schäfer, Lukas et al.**, “Visual encoders for data-efficient imitation learning in modern video games,” *arXiv*, 2023.
- [12] A. Krnjaic, J. D. Thomas, G. Papoudakis, **Schäfer, Lukas**, P. Börsting, and S. V. Albrecht, “Scalable multi-agent reinforcement learning for warehouse logistics with robotic and human co-workers,” *arXiv*, 2022.

### Theses

- [13] **Schäfer, Lukas**, *Curiosity in multi-agent reinforcement learning*, Master’s Thesis, 2019.
- [14] **Schäfer, Lukas**, *Domain-dependent policy learning using neural networks in classical planning*, Bachelor’s Thesis, 2018.

## REVIEWING

- 2023: NeurIPS, NeurIPS Datasets and Benchmark Track, ICML, AAMAS
- 2022: NeurIPS, NeurIPS Datasets and Benchmark Track, ICML (**top 10% outstanding reviewer award**), AAMAS
- 2021: NeurIPS
- 2020: Pre-registration experiment workshop at NeurIPS



## TEACHING AND SUPERVISION EXPERIENCE

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### Teaching Assistant, University of Edinburgh

10/2019 - 06/2022

REINFORCEMENT LEARNING, SCHOOL OF INFORMATICS

- › **Delivered lectures** and **designed coursework** on reinforcement learning (including deep and multi-agent RL) for last year undergraduate and M.Sc. students
- › **Supervised and marked coursework** and **exam scripts** for 100+ students

### M.Sc. Student Supervision, University of Edinburgh

02/2021 - 08/2021

- › Co-supervised two M.Sc. students through project proposal, refinement and execution towards final thesis
- › Rujie Zhong: Data Collection for Policy Evaluation in Reinforcement Learning  
Revised paper accepted at Workshop on Offline Reinforcement Learning at NeurIPS 2021, and later as a **main conference paper at NeurIPS 2022**
- › Panagiotis Kyriakou: Reinforcement Learning with Function Approximation in Continuing Tasks: Discounted Return or Average Reward?

### Voluntary Lecturer and Coach, Saarland University

09/2017 - 10/2017

MATHEMATICS PREPARATION COURSE

- › Delivered daily **lectures** on formal languages and predicate logic to **250 participants** in first week
- › The course received **BESTE-award** for special student commitment 2017 of Saarland University

### Teaching Assistant, Saarland University

10/2016 - 03/2017

PROGRAMMING 1, DEPENDABLE SYSTEMS AND SOFTWARE GROUP

- › Taught functional programming, basic complexity theory, and inductive proofs to first-year undergraduate students in weekly tutorials and office hours
- › Collectively created learning materials and discussed student progress as part of the whole teaching team
- › Marked weekly tests, mid-term and final exams



## AWARDS

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- › Principal's Career Development Scholarship 12/2019 - 06/2024
- › Top 10% outstanding reviewer award at ICML 2022 07/2022
- › DAAD graduate scholarship 09/2018 - 08/2019
- › Stevenson Exchange Scholarship 09/2018 - 08/2019
- › BESTE-award for special student commitment 2017 of Saarland University 10/2017

[REFERENCES AVAILABLE ON REQUEST]