Thomy Phan

Curriculum Vitae

Contact Information

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Research Interests

Multi-Agent Systems, Reinforcement Learning, Optimization

Education

2018 – 2023 **Ph.D. in Computer Science**, *LMU Munich*, Germany
- Thesis: *"Emergence and Resilience in Multi-Agent Reinforcement Learning"*
  - Thesis committee: Claudia Linnhoff-Popien, Sven Koenig, Long Tran-Thanh
  - Based on work published at AAMAS, AAAI, IJCAI, NeurIPS, and ICML

2015 – 2017 **M.Sc. in Computer Science**, *LMU Munich*, Germany
- Focus on artificial intelligence, data science, and autonomous systems
- Master thesis: *"EVADE: Emergent Value Function Approximation for Distributed Environments"*
  - Supervision: Claudia Linnhoff-Popien, Lenz Belzner
  - Results published at AAMAS 2018 as a **full conference paper**

2011 – 2015 **B.Sc. in Computer Science**, *Munich University of Applied Sciences*, Germany
- Collaborative study program (duales Studium) with the City of Munich
- Focus on software development and image processing
- Bachelor thesis: *"Quantification and Feature Extraction of 3D Single-Molecule Switching Microscopy Data"*
  - Supervision: Alfred Nischwitz, Joerg Bewersdorf
  - Practical work done at Bewersdorf Lab, Yale University
  - Results published in Cell 2016 as a **journal paper (cover story)**

Professional Experience

2023 – Present **Postdoctoral Scholar**, *University of Southern California*, Los Angeles, CA, USA
- Advisor: Sven Koenig
- Focus on multi-agent learning for optimization.

2018 – 2023 **Research Assistant**, *LMU Munich*, Germany
- Advisor: Claudia Linnhoff-Popien
- Focus on emergence and resilience in multi-agent systems.

2015 – 2018 **Software Developer (Part-Time)**, *it@M, City of Munich*, Germany
Development, maintainance, and integration of business applications.

Internships

2015 **Visiting Scholar in Research (3 Months)**, *Yale University*, New Haven, CT, USA
- Advisor: Joerg Bewersdorf
- Focus on data analysis and feature extraction of cellular structures in super-resolution microscopy data. Co-authored publication in Cell 2016 (cover story).

2012 – 2014 **Working Student (Collaborative Study Program)**, *City of Munich*, Germany
Regular internships focusing on IT architecture, project management, and software development during the semester holidays.

Honors and Awards

2024 **Nomination for the GI Dissertation Award 2023**, *German Informatics Society (GI)*, Dagstuhl, Germany
Nominated candidate by LMU Munich for the dissertation award of the German Informatics Society. The final decision will be made in summer/fall 2024.

2024 **CRA Travel Grant for the CCC Artificial Intelligence/Operations Research Workshop III**, *Computing Community Consortium (CCC)*, Washington, DC, USA
Invitation and financial support from the Computing Research Association (CRA).

2024 **ICAART 2024 – Springer Selection**, *Lecture Notes in Artificial Intelligence*
Invitation to submit an extended version of our ICAART 2024 paper *"Multi-Agent Quantum Reinforcement Learning using Evolutionary Optimization"* (co-author). Preprint at https://arxiv.org/pdf/2311.05546

2023 **Outstanding Reviewer (Top 10%)**, *Conference on Neural Information Processing Systems (NeurIPS)*, New Orleans, LA, USA
Listed at https://neurips.cc/Conferences/2023/ProgramCommittee

2022 **Premier Paper of AAMAS 2022**, *Journal of the International Foundation for Autonomous Agents and Multi-Agent Systems (JAAMAS)*
Invitation to submit an extended version of our AAMAS 2022 paper *"Emergent Cooperation from Mutual Acknowledgment Exchange"* (main author). Published at https://link.springer.com/article/10.1007/s10458-024-09666-5

2022 **Highlight Paper at the Workshop on Ad Hoc Teamwork**, *International Joint Conference on Artificial Intelligence (IJCAI)*, Vienna, Austria
Recognition of our AAMAS 2022 paper *"Emergent Cooperation from Mutual Acknowledgment Exchange"* (main author). More details at https://sites.google.com/view/ad-hoc-teamwork/waht-2022

2022 **Outstanding Reviewer (Top 10%)**, *International Conference on Machine Learning (ICML)*, Baltimore, MD, USA
Listed at https://icml.cc/Conferences/2022/Reviewers

2021 **ICAART 2021 – Springer Selection**, *Lecture Notes in Artificial Intelligence*
Invitation to submit an extended version of our ICAART 2021 paper *"SAT-MARL: Specification Aware Training in Multi-Agent Reinforcement Learning"* (co-author). Published at https://link.springer.com/chapter/10.1007/978-3-031-10161-8_1

2019 **DAAD Travel Grant for AAMAS 2019**, *German Academic Exchange Service*, Montreal, Canada

2016 **Best Bachelor Award**, *Rohde & Schwarz GmbH & Co. KG*, Munich, Germany

2016 **Award for an Outstanding Bachelor Thesis in the Field of Image Processing**, *Stemmer Imaging GmbH*, Munich, Germany

2012 – 2017 **Scholarship**, *German Academic Scholarship Foundation*, Munich, Germany
In Germany, the top 0.5% of university or high school students get selected for funding by the German Academic Scholarship Foundation.

Research Projects

2024 – Present **Causal Foundations of Decision-Making and Learning**, *National Science Foundation*, Los Angeles, CA, USA
Research on causal reinforcement learning and planning together with Columbia University and UC Irvine.

2023 – Present **AI4OPT – AI Institute for Advances in Optimization**, *National Science Foundation*, Los Angeles, CA, USA
Research on multi-agent learning for scalable optimization together with the Georgia Institute of Technology and UC Berkeley.

2023 **Dependability of Machine Learning in Industrial Robotics**, *Siemens AG*, Munich, Germany
Research on robust machine learning in industrial robotics. Assisted acquisition.

2022 – 2024 **Intelligent and Cognitive Systems**, *Bavarian Ministry of Economic Affairs, Regional Development, and Energy*, Munich, Germany
Research on emergence in multi-agent learning together with Fraunhofer IKS. Assisted acquisition.

2022 **Validation and Verification of Modular Machine Learning Systems**, *Siemens AG*, Munich, Germany
Research on modular machine learning. Assisted acquisition.

2020 – 2021 **Dependable MLOps in Industrial Environments**, *Siemens AG*, Munich, Germany
Research on adaptive testing in MLOps systems. Assisted acquisition.

2019 **Dependability of Machine Learning in Industrial Environments**, *Siemens AG*, Munich, Germany
Research on resilience in multi-agent reinforcement learning.

2018 **Coevolution in Machine Learning Based Industrial Environments**, *Siemens AG*, Munich, Germany
Research on scenario coevolution in reinforcement learning.

2018 – 2023 **InnoMI – Innovation Center Mobile Internet**, *Bavarian Ministry of Economic Affairs, Regional Development, and Energy*, Munich, Germany
Research on innovative mobile and distributed systems.

Selected Publications

Conferences

Extended abstracts (≤ 3 pages) with a full conference or journal version are not listed.

2024 [C20] **Adaptive Anytime Multi-Agent Path Finding using Bandit-Based Large Neighborhood Search**
Thomy Phan, Taoan Huang, Bistra Dilkina, and Sven Koenig.
AAAI Conference on Artificial Intelligence (**AAAI**), pages 17514–17522, 2024.

[C19] **Confidence-Based Curriculum Learning for Multi-Agent Path Finding**
Thomy Phan, Joseph Driscoll, Justin Romberg, and Sven Koenig.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 1558–1566, 2024.

[C18] **Anytime Multi-Agent Path Finding Using Operator Parallelism in Large Neighborhood Search (Extended Abstract)**
Shao-Hung Chan, Zhe Chen, Dian-Lun Lin, Yue Zhang, Daniel Harabor, Sven Koenig, Tsung-Wei Huang, and **Thomy Phan**.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 2183–2185, 2024.

[C17] **Multi-Agent Quantum Reinforcement Learning Using Evolutionary Optimization**
Michael Kölle, Felix Topp, **Thomy Phan**, Philipp Altmann, Jonas Nüßlein, Claudia Linnhoff-Popien.
International Conference on Agents and Artificial Intelligence (**ICAART**), pages 71–82, 2024.

[C16] **Challenges for Reinforcement Learning in Quantum Circuit Design**
Philipp Altmann, Jonas Stein, Michael Kölle, Adelina Bärligea, Maximilian Zorn, Thomas Gabor, **Thomy Phan**, Sebastian Feld and Claudia Linnhof-Popien.
IEEE International Conference on Quantum Computing and Engineering (**QCE**), 2024. To appear.

2023 [C15] **Attention-Based Recurrence for Multi-Agent Reinforcement Learning under Stochastic Partial Observability**
Thomy Phan, Fabian Ritz, Philipp Altmann, Maximilian Zorn, Jonas Nüßlein, Michael Kölle, Thomas Gabor, and Claudia Linnhoff-Popien.
International Conference on Machine Learning (**ICML**), pages 27840–27853, 2023.

[C14] **CROP: Towards Distributional-Shift Robust Reinforcement Learning using Compact Reshaped Observation Processing**
Philipp Altmann, Leonard Feuchtinger, Fabian Ritz, Jonas Nüßlein, Claudia Linnhoff-Popien, and **Thomy Phan**.
International Joint Conference on Artificial Intelligence (**IJCAI**), pages 3414–3422, 2023.

2022 [C13] **Emergent Cooperation from Mutual Acknowledgment Exchange**
Thomy Phan, Felix Sommer, Philipp Altmann, Fabian Ritz, Lenz Belzner, and Claudia Linnhoff-Popien.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 1047–1055, 2022.

[C12] **Towards Anomaly Detection in Reinforcement Learning (Blue Sky Ideas)**
Robert Müller, Steffen Illium, **Thomy Phan**, Tom Haider, and Claudia Linnhoff-Popien.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 1799–1803, 2022.

2021 [C11] **VAST: Value Function Factorization with Variable Agent Sub-Teams**
Thomy Phan, Fabian Ritz, Lenz Belzner, Philipp Altmann, Thomas Gabor, and Claudia Linnhoff-Popien.
Advances in Neural Information Processing Systems (**NeurIPS**), pages 24018–24032, 2021.

[C10] **Resilient Multi-Agent Reinforcement Learning with Adversarial Value Decomposition**
Thomy Phan, Lenz Belzner, Thomas Gabor, Andreas Sedlmeier, Fabian Ritz, and Claudia Linnhoff-Popien.
AAAI Conference on Artificial Intelligence (**AAAI**), pages 11308–11316, 2021.

[C9] **SAT-MARL: Specification Aware Training in Multi-Agent Reinforcement Learning**
Fabian Ritz, **Thomy Phan**, Robert Müller, Thomas Gabor, Andreas Sedlmeier, Marc Zeller, Jan Wieghardt, Reiner Schmid, Horst Sauer, Cornel Klein, and Claudia Linnhoff-Popien.
International Conference on Agents and Artificial Intelligence (**ICAART**), pages 28—37, 2021.

2020 [C8] **Learning and Testing Resilience in Cooperative Multi-Agent Systems**
Thomy Phan, Thomas Gabor, Andreas Sedlmeier, Fabian Ritz, Bernhard Kempter, Cornel Klein, Horst Sauer, Reiner Schmid, Jan Wieghardt, Marc Zeller, and Claudia Linnhoff-Popien.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 1055–1063, 2020.

[C7] **A Quantum Annealing Algorithm for Finding Pure Nash Equilibria in Graphical Games**
Christoph Roch, **Thomy Phan**, Sebastian Feld, Robert Müller, Thomas Gabor, Carsten Hahn, and Claudia Linnhoff-Popien.
International Conference on Computational Science (**ICCS**), pages 488–501, 2020.

2019 [C6] **Memory Bounded Open-Loop Planning in Large POMDPs using Thompson Sampling**
Thomy Phan, Lenz Belzner, Marie Kiermeier, Markus Friedrich, Kyrill Schmid, and Claudia Linnhoff-Popien.
AAAI Conference on Artificial Intelligence (**AAAI**), pages 7941–7948, 2019.

[C5] **Adaptive Thompson Sampling Stacks for Memory Bounded Open-Loop Planning**
Thomy Phan, Thomas Gabor, Robert Müller, Christoph Roch, and Claudia Linnhoff-Popien.
International Joint Conference on Artificial Intelligence (**IJCAI**), pages 5607–5613, 2019.

[C4] **Subgoal-Based Temporal Abstraction in Monte-Carlo Tree Search**
Thomas Gabor, Jan Peter, **Thomy Phan**, Christian Meyer, and Claudia Linnhoff-Popien.
International Joint Conference on Artificial Intelligence (**IJCAI**), pages 5562–5568, 2019.

[C3] **Distributed Policy Iteration for Scalable Approximation of Cooperative Multi-Agent Policies (Extended Abstract)**
Thomy Phan, Kyrill Schmid, Lenz Belzner, Thomas Gabor, Sebastian Feld, and Claudia Linnhoff-Popien.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 2162–2164, 2019.

[C2] **Scenario Co-Evolution for Reinforcement Learning on a Grid World Smart Factory Domain**
Thomas Gabor, Andreas Sedlmeier, Marie Kiermeier, **Thomy Phan**, Marcel Henrich, Monika Pichlmair, Bernhard Kempter, Cornel Klein, Horst Sauer, Reiner Schmid, and Jan Wieghardt.
Genetic and Evolutionary Computation Conference (**GECCO**), pages 898–906, 2019.

2018 [C1] **Leveraging Statistical Multi-Agent Online Planning with Emergent Value Function Approximation**
Thomy Phan, Lenz Belzner, Thomas Gabor, and Kyrill Schmid.
International Conference on Autonomous Agents and Multiagent Systems (**AAMAS**), pages 730–738, 2018.

Journals

2024 [J5] **Emergent Cooperation from Mutual Acknowledgment Exchange in Multi-Agent Reinforcement Learning**
Thomy Phan, Felix Sommer, Fabian Ritz, Philipp Altmann, Jonas Nüßlein, Michael Kölle, Lenz Belzner, and Claudia Linnhoff-Popien.
*Autonomous Agents and Multi-Agent Systems (***JAAMAS***)*, 38(34), 2024. Invited from AAMAS 2022.

2022 [J4] **Specification Aware Multi-Agent Reinforcement Learning**
Fabian Ritz, **Thomy Phan**, Robert Müller, Thomas Gabor, Andreas Sedlmeier, Marc Zeller, Jan Wieghardt, Reiner Schmid, Horst Sauer, Cornel Klein, and Claudia Linnhoff-Popien.
Springer Book of ICAART 2021, pages 3–21, 2022. Invited from ICAART 2021.

2021 [J3] **Productive Fitness in Diversity-Aware Evolutionary Algorithms**
Thomas Gabor, **Thomy Phan**, and Claudia Linnhoff-Popien.
Natural Computing, 20(3): 363–376, 2021.

2020 [J2] **The Scenario Coevolution Paradigm: Adaptive Quality Assurance for Adaptive Systems**
Thomas Gabor, Andreas Sedlmeier, **Thomy Phan**, Fabian Ritz, Marie Kiermeier, Lenz Belzner, Bernhard Kempter, Cornel Klein, Horst Sauer, Reiner Schmid, Jan Wieghardt, Marc Zeller, and Claudia Linnhoff-Popien.
*International Journal on Software Tools for Technology Transfer (***STTT***)*, 22(4): 457–476, 2020.

2016 [J1] **Ultra-High Resolution 3D Imaging of Whole Cells (Cover Story)**
Fang Huang, George Sirinakis, Edward S Allgeyer, Lena K Schroeder, Whitney C Duim, Emil B Kromann, **Thomy Phan**, Felix E Rivera-Molina, Jordan R Myers, Irnov Irnov, Mark Lessard, Yongdeng Zhang, Mary Ann Handel, Christine Jacobs-Wagner, C Patrick Lusk, James E Rothman, Derek Toomre, Martin J Booth, and Joerg Bewersdorf.
Cell, 166(4): 1028–1040, 2016.

Workshops

Workshop papers with a conference or journal version are not listed.

2023 [W3] **DIRECT: Learning from Sparse and Shifting Rewards using Discriminative Reward Co-Training**
Philipp Altmann, **Thomy Phan**, Fabian Ritz, Thomas Gabor, and Claudia Linnhof-Popien.
Adaptive and Learning Agents Workshop (**ALA**) at AAMAS, 2023.

2020 [W2] **The Holy Grail of Quantum Artificial Intelligence: Major Challenges in Accelerating the Machine Learning Pipeline**
Thomas Gabor, Leo Sünkel, Fabian Ritz, **Thomy Phan**, Lenz Belzner, Christoph Roch, Sebastian Feld, and Claudia Linnhoff-Popien.
International Workshop on Quantum Software Engineering (**Q-SE**) at ICSE 2020, pages 456–461, 2020.

[W1] **A Distributed Policy Iteration Scheme for Cooperative Multi-Agent Policy Approximation**
Thomy Phan, Lenz Belzner, Kyrill Schmid, Thomas Gabor, Fabian Ritz, Sebastian Feld, and Claudia Linnhoff-Popien.
Adaptive and Learning Agents Workshop (**ALA**) at AAMAS, 2020.

Academic Activities

Organizing Committee

2019 International Symposium on Applied Artificial Intelligence (ISAAI). More details at https://digitaleweltmagazin.de/digicon-2019/symposium/

Action Editor

2024 Transactions on Machine Learning Research (TMLR)

Program Committee

2021 – 2025 AAAI Conference on Artificial Intelligence (AAAI)
2022 – 2024 Conference on Neural Information Processing Systems (NeurIPS)
2023 – 2024 International Joint Conference on Artificial Intelligence (IJCAI)
2022 – 2024 International Conference on Machine Learning (ICML)
2024 International Conference on Automated Planning and Scheduling (ICAPS)
2024 International Conference on Learning Representations (ICLR)
2023 – 2024 European Conference on Artificial Intelligence (ECAI)
2024 Genetic and Evolutionary Computation Conference (GECCO)
2023 International Conference on Autonomous Agents and Multiagent Systems (AAMAS – Blue Sky Ideas)

Reviewer (of Individual Papers)

2024 Journal on Autonomous Agents and Multi-Agent Systems (JAAMAS)
2024 Artificial Intelligence Journal (AIJ)
2024 AAAI 2024 Workshop on Cooperative Multi-Agent Systems Decision-making and Learning (CMASDL)
2023 International Conference on Autonomous Agents and Multiagent Systems (AAMAS)
2018, 2022 International Symposium On Leveraging Applications of Formal Methods (ISoLA)
2021 PLOS ONE Journal
2020 International Journal on Software Tools for Technology Transfer (STTT)

Talks

Invited Talks

06/2024 **Reinforcement Learning-Based Multi-Agent Path Finding**, Bosch Research, Renningen, Germany (virtual)
Presentation of our AAMAS 2024 paper *"Confidence-Based Curriculum Learning for Multi-Agent Path Finding"* and the latest results of ongoing research.

06/2024 **Towards Scalable Optimization via Multi-Agent Reinforcement Learning**, *Interactive Visualization and Intelligence Augmentation Lab (IVIA)*, ETH Zürich (virtual), Switzerland
Invited talk at the IVIA-lab headed by Prof. Mennatallah El-Assady.

07/2022 **Emergent Cooperation from Mutual Acknowledgment Exchange**, Workshop on Ad Hoc Teamwork at IJCAI 2022 (virtual)
Highlight presentation of our AAMAS 2022 paper *"Emergent Cooperation from Mutual Acknowledgment Exchange"* (main author). More details at https://sites.google.com/view/ad-hoc-teamwork/waht-2022

06/2021 **Stability in AI-Systems**, Digitale Stadt München e.V., Germany (virtual)
DigiTalk event on Safe Intelligence of the Digital City Association of Munich. More details at https://digitalestadtmuenchen.de/event/safe-intelligence/

12/2020 **"Künstliche Intelligenz: Wie lernen Roboter?"**, Gymnasium Berchtesgaden, Germany (virtual)
P-seminar talk for high school students and the Junior Science Café. I received an invitation because of my successful talk at the Unitag event of LMU Munich in 2019 (see below).

03/2019 **Building Autonomous Systems with AI**, *University of Augsburg*, Germany
AI workshop for students of the Software Engineering Elite Graduate Program in Bavaria.

Presentations at Conferences as the Main Author

02/2024 **Adaptive Anytime Multi-Agent Path Finding Using Bandit-Based Large Neighborhood Search**, Vancouver, Canada
AAAI Conference on Artificial Intelligence (AAAI).

07/2023 **Attention-Based Recurrence for Multi-Agent Reinforcement Learning under Stochastic Partial Observability**, Honolulu, Hawaii, USA
International Conference on Machine Learning (ICML).

05/2022 **Emergent Cooperation from Mutual Acknowledgment Exchange**, virtual
International Conference on Autonomous Agents and Multiagent Systems (AAMAS).

12/2021 **VAST: Value Function Factorization with Variable Agent Sub-Teams**, virtual
Conference on Neural Information Processing Systems (NeurIPS).

02/2021 **Resilient Multi-Agent Reinforcement Learning with Adversarial Value Decomposition**, virtual
AAAI Conference on Artificial Intelligence (AAAI).

05/2020 **Learning and Testing Resilience in Cooperative Multi-Agent Systems**, virtual
International Conference on Autonomous Agents and Multiagent Systems (AAMAS).

08/2019 **Adaptive Thompson Sampling Stacks for Memory Bounded Open-Loop Planning**, Macao, China
International Joint Conference on Artificial Intelligence (IJCAI).

05/2019 **Distributed Policy Iteration for Scalable Approximation of Cooperative Multi-Agent Policies**, Montreal, Canada
International Conference on Autonomous Agents and Multiagent Systems (AAMAS).

02/2019 **Memory Bounded Open-Loop Planning in Large POMDPs using Thompson Sampling**, Honolulu, Hawaii, USA
AAAI Conference on Artificial Intelligence (AAAI).

07/2018 **Leveraging Statistical Multi-Agent Online Planning with Emergent Value Function Approximation**, Stockholm, Sweden
International Conference on Autonomous Agents and Multiagent Systems (AAMAS).

Other Talks

2019 **Unitag – "Künstliche Intelligenz: Wie lernen Roboter?"**, *LMU Munich*, Germany
University event for gifted high school students from Upper Bavaria.

Teaching

University of Southern California, USA

Spring 2024 **CSCI 599: Autonomous Decision-Making**
- New lecture on reinforcement learning, planning, and multi-agent systems
- Primary instructor
- Syllabus and registration count provided at https://classes.usc.edu/term-20241/course/csci-599/

Spring 2024 **CSCI 499: Foundations of Multi-Agent Systems (Guest Lecture)**
- Lecture on multi-agent algorithms and applications given by Prof. Sven Koenig
- Guest lecturer for two sessions on multi-agent reinforcement learning
- Syllabus and registration count provided at https://classes.usc.edu/term-20241/course/csci-499/

2023 – 2024 **Student Mentoring**
- 1 PhD student with one publication at *AAMAS 2024*
- 1 bachelor research project

LMU Munich, Germany

2019 – 2023 **Autonomous Systems**
- New practical course for 12 – 18 master students on planning and reinforcement learning
- Primary supervising assistant until summer semester 2022
- Syllabus and registration count for summer semester 2022 provided at https://uni2work.ifi.lmu.de/course/S22/IfI/ASP

2019 – 2023 **Working Group "Artificial Intelligence"**

- Voluntary working group for more than 100 bachelor and master students on current AI topics
- Primary supervising assistant
- Syllabus and registration count for summer semester 2022 provided at https://uni2work.ifi.lmu.de/course/S22/IfI/AIAG

Winter 2022 **Computational Intelligence (Guest Lecture)**

- Lecture on intelligent optimization algorithms given by Dr. Thomas Gabor
- Guest lecturer for one session on multi-agent optimization
- Syllabus and registration count provided at https://uni2work.ifi.lmu.de/course/W22/IfI/CoIn

2018 – 2019 **Mobile and Distributed Systems**

- Practical course for 12 – 18 master students on mobile app development and on-device machine learning
- Secondary supervising assistant

2018 – 2023 **Student Mentoring**

- 1 PhD student with one publication at *IJCAI 2023*
- 26 master theses with publications at *IJCAI 2019*, *AAMAS 2022*, and *JAAMAS 2024*.
- 24 bachelor theses with one student admitted to the *Max Planck Research School for Intelligent Systems (IMPRS-IS)* program for outstanding PhD students
- 8 individual research projects