

# KAIQING ZHANG

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## ACADEMIC EXPERIENCES

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| <b>Massachusetts Institute of Technology</b><br><b>Postdoctoral Scholar</b> at LIDS & CSAIL<br><b>Advisors:</b> Asu Ozdaglar; Russ Tedrake; Costis Daskalakis | May 2021 — Present     |
| <b>University of Illinois at Urbana-Champaign</b><br><b>Ph.D.</b> in Electrical and Computer Engineering<br><b>Advisor:</b> Tamer Başar                       | Aug. 2017 — May 2021   |
| <b>University of Illinois at Urbana-Champaign</b><br><b>M.S.</b> in Applied Mathematics & <b>M.S.</b> in Electrical and Computer Engineering                  | Aug. 2015 — Aug. 2017  |
| <b>Tsinghua University</b><br><b>B.S.</b> in Automation (with honor) & <b>Dual Degree</b> in Economics  | Sept. 2011 — Jul. 2015 |

## RESEARCH INTERESTS

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My research interests lie in the intersection of *control theory*, *game theory*, and *machine/reinforcement learning*, especially in *multi-agent* and *safety-critical* systems; with applications in intelligent and distributed cyber-physical systems, e.g., robotics, smart grid, and transportation systems. I resort to mathematical tools from the areas of Control Theory, Game Theory, Operations Research, and Probability Theory to develop *provably convergent* and *efficient* algorithms. Broadly speaking, the primary goal of my research is to lay theoretical foundations for the learning algorithms and systems that address (*data-driven*) *sequential-decision-making* problems in game theory and control theory, particularly in the presence of multiple decision-makers, towards *large-scale* and *reliable* autonomy.

## PUBLICATIONS

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### Book Chapter

- **Kaiqing Zhang**, Zhuoran Yang, and Tamer Başar, “Multi-Agent Reinforcement Learning: A Selective Overview of Theories and Algorithms”, *Studies in Systems, Decision and Control Handbook on Reinforcement Learning and Control*, Springer, 2020 (*Invited Chapter*).

### Journal Papers and Preprints

- Weichao Mao, **Kaiqing Zhang**, Ruihao Zhu, David Simchi-Levi, and Tamer Başar, “Model-free non-stationary RL: Near-Optimal regret and applications in multi-agent RL and inventory control”, *Management Science (MS)*, *under review*.
- Muhammed O. Sayin<sup>†</sup>, **Kaiqing Zhang**<sup>†</sup>, David S. Leslie, Tamer Başar, and Asuman Ozdaglar, “Decentralized Q-Learning in zero-sum Markov games” (<sup>†</sup> equal contribution), *under review*.
- **Kaiqing Zhang**<sup>†</sup>, Xiangyuan Zhang<sup>†</sup>, Bin Hu, and Tamer Başar, “Derivative-free policy optimization for risk-sensitive and robust control design: Implicit regularization and sample complexity” (<sup>†</sup> equal contribution), *under review*.
- **Kaiqing Zhang**, Sham M. Kakade, Tamer Başar, and Lin F. Yang, “Model-based multi-agent RL in zero-sum Markov games with near-optimal sample complexity”, *Journal of Machine Learning Research (JMLR)*, *under review*, preliminary version appeared in *NeurIPS 2020 (Spotlight)*.
- **Kaiqing Zhang**, Bin Hu, and Tamer Başar, “Policy optimization for  $\mathcal{H}_2$  linear control with  $\mathcal{H}_\infty$  robustness guarantee: Implicit regularization and global convergence”, *SIAM Journal on Control and Optim. (SICON)*, 2021.

- **Kaiqing Zhang**, Zhuoran Yang, Han Liu, Tong Zhang, and Tamer Başar, “Finite-sample analysis for decentralized batch multi-agent reinforcement learning with networked agents”, *IEEE Trans. on Automatic Control (TAC)*, 2021.
- Tianyi Chen, **Kaiqing Zhang**, Georgios B. Giannakis, and Tamer Başar, “Communication-efficient distributed reinforcement learning”, *IEEE Trans. on Control of Network Systems (TCNS)*, 2021.
- **Kaiqing Zhang**, Alec Koppel, Hao Zhu, and Tamer Başar, “Global convergence of policy gradient methods to (almost) locally optimal policies”, *SIAM Journal on Control and Optim. (SICON)*, 2020.
- Alec Koppel<sup>†</sup>, **Kaiqing Zhang**<sup>†</sup>, Hao Zhu, and Tamer Başar, “Projected stochastic primal-dual method for constrained online learning with kernels” († equal contribution), *IEEE Trans. on Signal Process. (TSP)*, vol. 67, no. 10, pp. 2528-2542, May, 2019.
- **Kaiqing Zhang**, Yang Liu, Ji Liu, Mingyan Liu, and Tamer Başar, “Distributed learning of average belief over networks using sequential observations,” *Automatica*, vol. 115, May 2020.
- **Kaiqing Zhang**, Liqun Lu, Chao Lei, Hao Zhu, and Yanfeng Ouyang, “Dynamic operations and pricing of electric unmanned aerial vehicle systems and power networks,” *Journal of Transportation Research Part C: Emerging Technologies*, vol. 92, pp. 472-485, July 2018.
- **Kaiqing Zhang**, Wei Shi, Hao Zhu, Emiliano Dall’Anese, and Tamer Başar, “Dynamic power distribution system management with a locally connected communication network,” *IEEE Journal of Selected Topics in Signal Process. (JSTSP)*, vol. 12, no. 4, pp. 673-687, May 2018.
- Hanchen Xu, **Kaiqing Zhang**, and Junbo Zhang, “Optimal joint bidding and pricing of profit-seeking load serving entity,” *IEEE Trans. on Power Systems (TPS)*, vol. 33, no. 5, pp. 5427-5436, March 2018.
- **Kaiqing Zhang**, Siming Guo, and Hao Zhu, “Dependency analysis and improved parameter estimation for complex dynamic load modeling,” *IEEE Trans. on Power Systems (TPS)*, vol. 32, no. 4, pp. 3287-3297, Nov. 2016.

### Conference Papers

- Weichao Mao, **Kaiqing Zhang**, Ruihao Zhu, David Simchi-Levi, and Tamer Başar, “Near-optimal model-free reinforcement learning in non-stationary episodic MDPs”, *Intl. Conf. on Machine Learning (ICML)*, 2021.
- Wesley Suttle, **Kaiqing Zhang**, Zhuoran Yang, Ji Liu, and David Kraemer, “Reinforcement learning for cost-aware Markov decision processes”, *Intl. Conf. on Machine Learning (ICML)*, 2021.
- Zengyi Qin, **Kaiqing Zhang**, Yuxiao Chen, Jingkai Chen, and Chuchu Fan, “Learning safe multi-agent control with decentralized neural barrier certificates,” *Intl. Conf. on Learning Represent. (ICLR)*, 2021.
- **Kaiqing Zhang**, Sham M. Kakade, Tamer Başar, and Lin F. Yang, “Model-based multi-agent RL in zero-sum Markov games with near-optimal sample complexity”, *Neural Info. Process. Systems (NeurIPS)*, 2020 (**Spotlight, top 2.96%, 280 out of 9454 submissions**).
- **Kaiqing Zhang**, Bin Hu, and Tamer Başar, “On the stability and convergence of robust adversarial reinforcement learning: A case study on linear quadratic systems,” *Neural Info. Process. Systems (NeurIPS)*, 2020.
- **Kaiqing Zhang**<sup>†</sup>, Tao Sun<sup>†</sup>, Yunzhe Tao, Sahika Genc, Sunil Mallya, and Tamer Başar, “Robust multi-agent reinforcement learning with model uncertainty” († equal contribution), *Neural Info. Process. Systems (NeurIPS)*, 2020.
- Dongsheng Ding, **Kaiqing Zhang**, Tamer Başar, and Mihailo R. Jovanovic, “Natural policy gradient primal-dual method for constrained Markov decision processes,” *Neural Info. Process. Systems (NeurIPS)*, 2020.
- Weichao Mao, **Kaiqing Zhang**, Qiaomin Xie, and Tamer Başar, “POLY-HOOT: Monte-Carlo planning in continuous space MDPs with non-asymptotic analysis”, *Neural Info. Process. Systems (NeurIPS)*, 2020.
- Yanli Liu, **Kaiqing Zhang**, Tamer Başar, and Wotao Yin, “An improved analysis of (variance-reduced) policy gradient and natural policy gradient methods”, *Neural Info. Process. Systems (NeurIPS)*, 2020.

- Weichao Mao, **Kaiqing Zhang**, Erik Miehling, and Tamer Başar, “Information state embedding in partially observable cooperative multi-agent reinforcement learning,” *IEEE Conf. on Decision and Control (CDC)*, 2020.
- Muhammad Aneeq uz Zaman, **Kaiqing Zhang**, Erik Miehling, and Tamer Başar, “Reinforcement learning in non-stationary discrete-time linear-quadratic mean-field games,” *IEEE Conf. on Decision and Control (CDC)*, 2020.
- **Kaiqing Zhang**, Bin Hu, and Tamer Başar, “Policy optimization for  $\mathcal{H}_2$  linear control with  $\mathcal{H}_\infty$  robustness guarantee: Implicit regularization and global convergence,” *Learning for Dynamics & Control (L4DC) Conference (Oral, top 10%, 14 out of all submissions)*, 2020.
- **Kaiqing Zhang**, Zhuoran Yang, and Tamer Başar, “Policy optimization provably converges to Nash equilibria in zero-sum linear quadratic games”, *Neural Info. Process. Systems (NeurIPS)*, 2019.
- Xiangyuan Zhang, **Kaiqing Zhang**, Erik Miehling, and Tamer Başar, “Non-Cooperative Inverse Reinforcement Learning”, *Neural Info. Process. Systems (NeurIPS)*, 2019.
- **Kaiqing Zhang**, Erik Miehling, and Tamer Başar, “Online planning for decentralized stochastic control with partial history sharing,” *IEEE American Control Conf. (ACC)*, 2019.
- **Kaiqing Zhang**, Zhuoran Yang, and Tamer Başar, “Networked multi-agent reinforcement learning in continuous spaces”, *IEEE Conf. on Decision and Control (CDC)*, 2018.
- Zhuoran Yang, **Kaiqing Zhang**, Mingyi Hong, and Tamer Başar, “A finite sample analysis of the actor-critic algorithm”, *IEEE Conf. on Decision and Control (CDC)*, 2018.
- **Kaiqing Zhang**, Zhuoran Yang, Han Liu, Tong Zhang, and Tamer Başar, “Fully decentralized multi-agent reinforcement learning with networked agents”, *Intl. Conf. on Machine Learning (ICML)*, 2018.
- **Kaiqing Zhang**, Zhuoran Yang, and Zhaoran Wang, “Nonlinear structured signal estimation in high dimensions via iterative hard thresholding,” *Intl. Conf. on Artificial Intelligence and Statistics (AISTATS)*, 2018.
- **Kaiqing Zhang**, Yuan Shen, and Moe Z. Win, “On the performance of map-aware cooperative localization,” *IEEE Intl. Conf. on Commun. (ICC)*, 2016.

## OTHER ACADEMIC EXPERIENCES

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<b>Visiting Graduate Student</b>	Simons Institute, UC Berkeley (virtual)	Aug. 2020 — Dec. 2020
<b>Research Scientist Intern</b>	Amazon AWS AI Labs, Seattle, WA	May 2019 — Aug. 2019
<b>Visiting Fellowship</b>	Army Research Lab. (ARL), Adelphi, MD	Jun. 2018 — Aug. 2018
<b>Research Scientist Intern</b>	Nation. Renew. Energy Lab. (NREL), CO	Jun. 2016 — Sept. 2016

## TEACHING EXPERIENCES

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<b>Teaching Assistant</b>	ECE 543 Statistical Learning Theory by Prof. R. Srikant	Spring 2020
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## PATENTS

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U.S. Patent No. 908486	Robust Actor/Critic Multi-Agent RL for Mobile Robotics Applications
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## AWARDS & HONORS

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· Simons-Berkeley Research Fellowship, Simons Institute & UC Berkeley	2022
· Linde + CAST Postdoctoral Scholar Fellowship, Caltech CMS & CSIS (declined)	2021
· Kuck Computational Science & Engineering Scholarship, UIUC	2020
· Hong, McCully, and Allen Fellowship ( <b>\$12000</b> ), UIUC	2018 & 2019 & 2020
· YEE Fellowship Award, College of Engineering, UIUC	2020
· NeurIPS Travel Award	2019

· CDC Student Travel Award	2019 & 2020
· Mavis Future Faculty Fellows (MF3), UIUC	2019
· ICML Travel Award	2018
· James M. Henderson Fellowship, UIUC	2016
· Beijing Outstanding Undergraduate Thesis	2015
· National Scholarship ( <b>top 3%</b> ), Tsinghua University	2014
· <b>Meritorious Winner</b> 2014 Mathematical Contest in Modeling	2014
· <b>First Prize</b> in 34th Challenge Cup of Tsinghua University	2014
· <b>Third place</b> in competition of Adult-Size Group in RoboCup	2013
· Comprehensive First-Class Scholarship of Tsinghua University ( <b>top 5%</b> )	2012 & 2013
· <b>First Prize</b> of National Physics Olympiad, with Pre-Admission to Tsinghua University	2011

## PROFESSIONAL SERVICES & ACTIVITIES

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- Co-organizer of the online seminar series *Games, Decisions & Networks*
- Reviewer for *ICML*, *NeurIPS*, *ICLR*, *AAAI*, *Mathematical Programming*, *IEEE Trans. Automatic Control (TAC)*, *Automatica*, *IEEE Journal of Selected Topics in Signal Processing (JSTSP)*, *IEEE Trans. Smart Grid (TSG)*, *IEEE Trans. Power Systems (TPS)*, *IEEE Control Systems Letters (L-CSS)*, *IEEE Communications Letters (CL)*, *System & Control Letters*, *IEEE American Control Conf. (ACC)*, *IEEE Control and Decision Conf. (CDC)*, *Learning for Dynamics & Control Conf. (L4DC)*, *IEEE Intl. Conf. on Communications (ICC)*
- Organizer of the invited sessions *Machine Learning in Complex Networks* at *IEEE Control and Decision Conf. (CDC)*, 2018, 2019
- President of *Tsinghua University Alumni Association (THU-AA)* in UIUC      Sept. 2019 — June 2021
- Committee of the 8th *IEEE Power and Energy Conf. at Illinois (PECI)*      April 2016 — Feb. 2017
- Vice-President of the *Student Union* of the Dept. of Automation      Aug. 2013 — Aug. 2014