Laixi Shi

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Academic Experience

2023.8 – Pre **Postdoctoral Fellow, Computing + Mathematical Sciences**,
California Institute of Technology, CA, USA,
Supervisors: Adam Wierman and Eric Mazumdar.

Education

2018.8 – 2023.8 **Ph.D. Candidate, Electrical and Computer Engineering**,
Carnegie Mellon University, PA, USA,
Advisor: Yuejie Chi.

2014.9 – 2018.7 **B.Eng., Electronic Engineering**, *Tsinghua University*, Beijing, China,
Working with Yimin Liu.

Honors & Awards

Honors/Fellowships:

- 2024 CMU ECE A.G. Milnes Award — the PhD thesis work judged to be of the highest quality and which has had or is likely to have significant impact in his or her field
- 2023 Rising Stars In Machine Learning by University of Maryland
- 2023 Computing, Data, and Society Postdoctoral Fellow by Caltech
- 2023 ICASSP Rising Stars in Signal Processing
- 2023 UT Austin Rising Stars in Computational and Data Sciences
- 2022 UChicago Rising Stars in Data Science
- 2022 NeurIPS 2022 Top Reviewer
- 2022 Leo Finzi Memorial Fellowship
- 2022 Wei Shen and Xuehong Zhang Presidential Fellowship
- 2021 Liang Ji-Dian Graduate Fellowship
- 2018 Presidential Fellowship granted by Carnegie Mellon University
- 2018 Carnegie Institute of Technology Dean's Fellowship
- 2018 Excellent Honors Graduate granted by Tsinghua University
- 2017 The First Prize in 35th Tsinghua University Academic Challenge Cup
- 2015-2017 Technology Innovation Excellence Award granted by Tsinghua University
- 2017 Enterprise Sponsored Scholarship granted by Tsinghua University
- 2016 National Scholarship granted by the government of China
- 2016 Qualcomm Scholarship granted by Tsinghua University
- 2016 Outstanding Project of Undergraduate Research Competition of Tsinghua University
- 2015 The First Prize in National Physics Contest for College Student
- 2014 The Silver Medal of Chinese Physics Olympiad

Travel Awards:

- 2024 ISyE Junior Researcher Workshop Travel Support by Georgia Tech
- 2022 IAS WAM Mathematics in Machine Learning Travel Support

2020	National Science Foundation (NSF) Student Travel Grants for ICASSP
2020	Computing Research Association Grad Cohort for Women Travel Support
2019	The ACM International Workshop on Device-Free Human Sensing Travel Grant
2019	Women in Machine Learning Scholarship
2019	Women in Data Science and Mathematics Travel Support

Research Interests

My research interests focus on designing efficient algorithms for sequential decision making, data science and signal processing by leveraging tools from machine learning, high-dimensional statistics, and large-scale optimization. My contributions span across theory and applications, from providing theoretical footings to heuristics to advancing real-world applications as follows:

- **Enhancing sample efficiency and robustness for reinforcement learning:** designing sample-efficient value-based algorithms for online, offline and robust reinforcement learning with theoretical guarantees.
- **Nonconvex optimization for data science and signal processing:** developing provably efficient and theory-inspired nonconvex optimization methods for signal and data processing by leveraging low-dimensional representation.
- **Real-world application solutions**: seeking data-driven and physics-driven solutions for various sensing, computing, and robotics systems, with collaborators in civil engineering, the robotics institute, high-performance computing, mechanical engineering and industry.

Professional Experience

2022.9-2022.12	**Google Research, Brain Team**, *Mountain View, United States*, Student Researcher, Mentor: Pablo Samuel Castro, Matthieu Geist, Robert Dadashi. We work on designing deep reinforcement learning algorithms by resorting to some regularization techniques in offline RL.
2022.6-2022.9	**Google Research, Brain Team**, *Paris, France*, Research Intern, Mentor: Matthieu Geist, Robert Dadashi. We work on a project to design efficient deep reinforcement learning algorithms, which includes but not limited to the topics about game theory and optimization.
2020.5-2020.8	**Mitsubishi Electric Research Laboratories (MERL)**, *Boston, United States*, Research Intern, Mentor: Dehong Liu. This confidential project involves blind deconvolution, image fusion and stitching, abnormal estimation detection of a sequence of problems, low rank matrix reconstruction, and sparsity.
2017.3-2017.6	**Momenta**, *Beijing, China*, Software Engineering Intern, Mentor: Gang Sun, Le Shan. I worked on computer graphics by displaying the HD semantic mapping of the road condition extracted by the deep-learning based perception system of the autonomous vehicles, which used to demonstrate the effect of the real-time "brains" for full autonomous driving.

Publications & Preprints

∗ represents equal contribution or alphabetical order.

Reinforcement Learning: Theory

[1] <u>Laixi Shi</u>, Eric Mazumdar, Yuejie Chi, Adam Wierman. "Sample-Efficient Robust Multi-Agent Reinforcement Learning in the Face of Environmental Uncertainty" *International Conference on Machine Learning (ICML)*, 2024.

[2] Jiin Woo, <u>Laixi Shi</u>, Gauri Joshi, Yuejie Chi. "Federated Offline Reinforcement Learning: Collaborative Single-Policy Coverage Suffices" *International Conference on Machine Learning (ICML)*, 2024.

[3] He Wang, <u>Laixi Shi</u>, Yuejie Chi. "Sample Complexity of Offline Distributionally Robust Linear Markov Decision Processes" *Reinforcement Learning Conference (RLC)*, 2024

[4] Eric Mazumdar*, Kishan Panaganti*, <u>Laixi Shi</u>*. "Tractable Equilibrium Computation in Markov Games through Risk Aversion" *Preprint*.

[5] Zhengfei Zhang, Kishan Panaganti, <u>Laixi Shi</u>, Yanan Sui, Adam Wierman, Yisong Yue. "Distributionally Robust Constrained Reinforcement Learning under Strong Duality" *International Conference on Machine Learning (ICML)*, 2024.

[6] <u>Laixi Shi</u>, Gen Li, Yuting Wei, Yuxin Chen, Matthieu Geist, Yuejie Chi. "The Curious Price of Distributional Robustness in Reinforcement Learning with a Generative Model" Short version at *Conference on Neural Information Processing Systems (NeurIPS)*, 2023

[7] <u>Laixi Shi</u>, Yuejie Chi. "Distributionally Robust Model-Based Offline Reinforcement Learning with Near-Optimal Sample Complexity" *In submission*.

[8] Gen Li, <u>Laixi Shi</u>, Yuxin Chen, Yuejie Chi, Yuting Wei. "Settling the Sample Complexity of Model-Based Offline Reinforcement Learning" *The Annals of Statistics*.

[9] <u>Laixi Shi</u>, Gen Li, Yuxin Chen, Yuting Wei, Yuejie Chi. "Pessimistic Q-Learning for Offline Reinforcement Learning: Towards Optimal Sample Complexity" *International Conference on Machine Learning (ICML)*, 2022.

[10] Gen Li, <u>Laixi Shi</u>, Yuxin Chen, Yuejie Chi. "Breaking the Sample Complexity Barrier to Regret-Optimal Model-Free Reinforcement Learning" *Information and Inference: A Journal of the IMA*. A short version has been accepted by *Conference on Neural Information Processing Systems (NeurIPS)*, 2021 (**NeurIPS Spotlight**).

Reinforcement Learning: Practice

[11] Shangding Gu*, <u>Laixi Shi*</u>, Yuhao Ding, Alois Knoll, Costas Spanos, Adam Wierman, Ming Jin. "Enhancing Efficiency of Safe Reinforcement Learning via Sample Manipulation" *Preprint*.

[12] Wenhao Ding*, <u>Laixi Shi*</u>, Yuejie Chi, Ding Zhao. "Seeing is not Believing: Robust Reinforcement Learning against Spurious Correlation" *Conference on Neural Information Processing Systems (NeurIPS)*, 2023.

[13] <u>Laixi Shi</u>, Robert Dadashi, Yuejie Chi, Pablo Samuel Castro, Matthieu Geist. "Offline Reinforcement Learning with On-Policy Q-Function Regularization" *European Conference on Machine Learning (ECML)*, 2023.

[14] Yiqi Wang, Mengdi Xu, <u>Laixi Shi</u>, Yuejie Chi. "A Trajectory is Worth Three Sentences: Multimodal Transformer for Offline Reinforcement Learning" Accepted by *The Conference on Uncertainty in Artificial Intelligence (UAI)*, 2023.

[15] Peide Huang, Mengdi Xu, Jiacheng Zhu, <u>Laixi Shi</u>, Fei Fang, Ding Zhao. "Curriculum Reinforcement Learning using Optimal Transport via Gradual Domain Adaptation" *Conference on Neural Information Processing Systems (NeurIPS)*, 2022.

Data Science and Signal Processing

[16] <u>Laixi Shi</u> and Yuejie Chi. "Manifold Gradient Descent Solves Multi-channel Sparse Blind Deconvolution Provably and Efficiently." *IEEE Transactions on Information Theory, vol. 67, no. 7, pp. 4784-4811,* 2021. Short version at *International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2020.

[17] <u>Laixi Shi</u>, Dehong Liu, Jay Thornton. "Robust Camera Pose Estimation For Image Stitching" *IEEE International Conference on Image Processing (ICIP)*, 2021. Another version at *U.S. Patent Application 17/214,813*, 2022.

[18] Sang Yu, <u>Laixi Shi</u>, and Yimin Liu. "Micro hand gesture recognition system using ultrasonic active sensing." *IEEE Access, vol. 6, pp. 49339-49347*, 2018.

Real-World Applications

[19] T. Low, Y. Chi, J. Hoe, S. Kumar, A. Prabhakara, <u>L. Shi</u>, U. Sridhar, N. Tukanov, C. Wang, and Y. Wu. "Zoom Out: Abstractions for Efficient Radar Algorithms on COTS Architectures." *IEEE International Symposium on Phased Array Systems and Technology (PAST)*, 2022.

[20] <u>Laixi Shi</u>*, Peide Huang*, Rui Chen*. "Latent Goal Allocation for Multi-Agent Goal-Conditioned Self-Supervised Learning." *NeurIPS Bayesian Deep Learning Workshop*, 2021. (* = equal contribution)

[21] <u>Laixi Shi</u>, Dehong Liu, Masaki Umeda, and Norihiko Hana. "Fusion-Based Digital Image Correlation Framework for Strain Measurement." *International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2021. Another version at *U.S. Patent Application 17/148,609*, 2022.

[22] <u>Laixi Shi</u>, Yue Zhang, Shijia Pan, and Yuejie Chi. "Data Quality-Informed Multiple Occupant Localization using Floor Vibration Sensing." *The 21st International Workshop on Mobile Computing Systems and Applications*, 2020.

[23] <u>Laixi Shi</u>, Mostafa Mirshekari, Jonathon Fagert, Yuejie Chi, Hae Young Noh, Pei Zhang, and Shijia Pan. "Device-free Multiple People Localization through Floor Vibration." *First ACM Workshop on Device-Free Human Sensing*, 2019.

Patents

[1] Dehong Liu, <u>Laixi Shi</u>. "System and Method of Image Stitching using Robust Camera Pose Estimation." *US Patent App. 17/214,813*, 2022.

[2] Dehong Liu, <u>Laixi Shi</u>, Masaki Umeda, and Norihiko Hana. "Fusion-Based Digital Image Correlation Framework for Strain Measurement" *US Patent App. 17/148,609*, 2022.

Student Mentorship

CMU ECE	Yuchen Wu (master student → Ph.D. student at UW), 2021-2022
	Gore Kao (master student → Tiktok), 2022-2023
	Yiqi Wang (master student), 2022-Present
Caltech CMS	Chenbei Lu (visiting Ph.D. student), 2023-Present
	Zhengfei Zhang (visiting undergraduate student), 2023-Present
	Chengrui Qu (visiting undergraduate student), 2024-Present

Selected Professional Services

Area Chair:	Conference on Parsimony and Learning (CPAL).
Organization:	Breakout session leader at *3rd Women in Machine Learning Un-Workshop, ICML 2022*.
Review:	*Journal:* FoCM, TPAMI, TIT, TSP, OR, MOR, JMLR.
	Conferences: ICLR (2022-2023), ICASSP (2022-2023), ICML (2020-2024), CHIL (2022), NeurIPS (2021-2022,2024), ISIT (2022), ECML(2023), ICRA(2023).
	Workshops: SSP (2021), WiML (2019).

Teaching Experience

2020 Spring	18202 Mathematical Foundations of Electrical Engineering, Grad TA, CMU ECE Department.
2021 Spring	18202 Mathematical Foundations of Electrical Engineering, Grad TA, CMU ECE Department.
2024 Summer	Reinforcement Learning Bootcamp, Instructor, Caltech.

Presentations

Talks

2024.4	The Power of Distributional Robustness. *Georgia Tech ISyE Junior Researcher Workshop.*
2024.2	The Cost of Distributional Robustness in Reinforcement Learning: Minimax-Optimal Sample Efficiency. *Information Theory and Applications Workshop (ITA).*
2023.11	The Cost of Distributional Robustness in Reinforcement Learning: Minimax-Optimal Sample Efficiency. *Rising Stars In Machine Learning, University of Maryland.*
2023.11	The Cost of Distributional Robustness in Reinforcement Learning: Minimax-Optimal Sample Efficiency. *WORDS 2023: Workshop in Operations Research and Data Science, Duke University*
2023.10	The Cost of Distributional Robustness in Reinforcement Learning: Minimax-Optimal Sample Efficiency. *Safe Reinforcement Learning Online Seminar*
2023.10	The Cost of Distributional Robustness in Reinforcement Learning: Minimax-Optimal Sample Efficiency. *2023 INFORMS Annual Meeting*
2023.10	Sample-Efficient Artificial Intelligence. *IST ADVISORY COUNCIL MEETING at Caltech*
2023.9	The Curious Price of Distributional Robustness in Reinforcement Learning: Towards provable optimal sample efficiency. *RSRG/FALCON Tea Talk at Caltech*
2023.4	Provable Algorithms for Reinforcement Learning: Efficiency and Robustness. *UT Austin Rising Stars in Computational and Data Sciences*
2023.2	Offline Reinforcement Learning: Towards Optimal Sample Complexity and Distributional Robustness. *Computer Science & Engineering at University of Connecticut*
2023.2	Provable Algorithms for Reinforcement Learning: Efficiency and Robustness. *Information Theory and Applications Workshop (ITA)*
2023.1	Offline Reinforcement Learning: Towards Optimal Sample Complexity and Distributional Robustness. *Air Force Center of Excellence Meeting*
2022.11	Provable Algorithms for Reinforcement Learning: Efficiency and Robustness. *UChicago Rising Stars in Data Science (2022)*
2022.9	Reinforcement learning based on game theory, stochastic composition optimization and regularization. *Intern presentation at Google Brain*
2022.3	Manifold Gradient Descent Solves Multi-Channel Sparse Blind Deconvolution Provably and Efficiently. *SIAM Conference on Imaging Science (IS22)*
2021.8	Multi-channel Sparse Blind Deconvolution via Nonconvex Optimization. *IEEE East Asian School of Information Theory (2021)*
2020.8	Fusion-Based Digital Image Correlation Framework for Strain Measurement. *Intern presentation at Mitsubishi Electric Research Laboratories (MERL)*
2020.7	Nonconvex Optimization for Multi-channel Sparse Blind Deconvolution. *Optimization interest seminar in Mitsubishi Electric Research Laboratories (MERL)*

Poster presentations at conferences/workshops

2023.10 Provable Algorithms for Reinforcement Learning: Efficiency and Robustness. *2023 INFORMS Annual Meeting QSR Poster Competition Session*

2023.6 Provable Algorithms for Reinforcement Learning: Efficiency and Robustness. *ICASSP Rising Stars in Signal Processing*

2022.12 Curriculum Reinforcement Learning using Optimal Transport via Gradual Domain Adaptation. *Conference on Neural Information Processing Systems (NeurIPS)*, 2022

2022.7 Pessimistic Q-Learning for Offline Reinforcement Learning: Towards Optimal Sample Complexity. *International Conference on Machine Learning (ICML)*, 2022

2021.12 Breaking the Sample Complexity Barrier to Regret-Optimal Model-Free Reinforcement Learning. *Conference on Neural Information Processing Systems (NeurIPS)*, 2021

2021.9 Robust camera pose estimation for image stitching. *IEEE International Conference on Image Processing (ICIP)*, 2021

2021.6 Fusion-Based Digital Image Correlation Framework for Strain Measurement. *International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2021

2019.12 Nonconvex Optimization for Multi-channel Sparse Blind Deconvolution. *Women in Machine Learning at NeurIPS*, 2019

2019.11 Device-free Multiple People Localization through Floor Vibration. *First ACM Workshop on Device-Free Human Sensing*, 2019