Laixi Shi

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Education

2018 – Present **Ph.D. Candidate, Electrical and Computer Engineering**, *Carnegie Mellon University, PA, USA*,
Advisor: Yuejie Chi.

2014 – 2018 **B.Eng., Electronic Engineering**, *Tsinghua University*, Beijing, China,
Working with Yimin Liu.

Honors & Awards

Honors/Fellowships:

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:

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 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.

Work Experience

2018.9-Present **Carnegie Mellon University**, *Pittsburgh, United States*,
Research Assistant, Advisor: Yuejie Chi.
We seek sample-, computation- and memory-efficient algorithms for various problems in reinforcement learning, signal processing, and machine learning.

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

Reinforcement Learning

[1] Laixi Shi, Gen Li, Yuting Wei, Yuxin Chen, Matthieu Geist, Yuejie Chi. "The Curious Price of Distributional Robustness in Reinforcement Learning with a Generative Model" *In submission*.

[2] Wenhao Ding, Laixi Shi, Yuejie Chi, Ding Zhao. "Seeing is not Believing: Robust Reinforcement Learning against Spurious Correlation" *In submission*.

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

[4] Yiqi Wang, Mengdi Xu, Laixi Shi, 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.

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

[6] Gen Li, Laixi Shi, Yuxin Chen, Yuejie Chi, Yuting Wei. "Settling the Sample Complexity of Model-Based Offline Reinforcement Learning" *In submission*.

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

[8] Laixi Shi, 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.

[9] Gen Li, Laixi Shi, Yuxin Chen, Yuejie Chi. "Breaking the Sample Complexity Barrier to Regret-Optimal Model-Free Reinforcement Learning" Accepted by *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**).

Data Science and Signal Processing

[10] Laixi Shi 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.

[11] Laixi Shi, 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.

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

Real-World Applications

[13] T. Low, Y. Chi, J. Hoe, S. Kumar, A. Prabhakara, L. Shi, 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.

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

[15] Laixi Shi, 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.

[16] Laixi Shi, 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.

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

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

Research Experience

2022.3-Present **Provable Algorithm Design for Distributionally Robust Reinforcement Learning**,
Dept. of Electrical and Computer Engineering, Carnegie Mellon University,
Research Assistant, Advisor: Yuejie Chi.
We propose sample efficient model-based algorithms for distributionally robust online and offline reinforcement learning with different uncertainty sets.

2020.9-Present **Sample Complexity Analysis for Offline/Online Reinforcement Learning Algorithms**,
Dept. of Electrical and Computer Engineering, Carnegie Mellon University,
Research Assistant, Advisor: Yuejie Chi, Yuxin Chen, Yuting Wei.
We propose sample efficient model-free/model-based algorithms for online and offline reinforcement learning and provide non-asymptotic convergence guarantee for the proposed algorithms.

2019.12-Present **Self-Calibrated Compressive Sensing via Nonconvex Optimization**,
Dept. of Electrical and Computer Engineering, Carnegie Mellon University,
Research Assistant, Advisor: Yuejie Chi.
We propose an efficient and provable nonconvex optimization approach for self-calibrated compressive sensing, which is an important extension of multi-channel sparse blind deconvolution in the overcomplete case.

2018.9–2019.11 **Multi-Channel Sparse Blind Deconvolution via Nonconvex Optimization**,
Dept. of Electrical and Computer Engineering, Carnegie Mellon University,
Research Assistant, Advisor: Yuejie Chi.
We propose an efficient and provable nonconvex optimization approach for multi-channel sparse blind deconvolution based on manifold gradient descent with random initialization.

2018.9–2020.3 **Multiple Occupants Localization through Vibration Sensing**,
Dept. of Electrical and Computer Engineering, Carnegie Mellon University, Pittsburgh, USA,
Research Assistant, Advisor: Yuejie Chi, Shijia Pan, Pei Zhang, Hae Young Noh.
We propose a non-intrusive pedestrian sensing system that localizes multiple pedestrians walking in a sensing area through ambient structural vibrations.

2016.8–2018.8 **Micro Hand Gesture Recognition System using Ultrasonic Active Sensing**,
Dept. of Electronic Engineering, Tsinghua University, Beijing, China,
Research Assistant, Advisor: Yimin Liu.
We proposed a system, which uses micro dynamic hand gestures for recognition to achieve human–computer interaction (HCI). The implemented system, called hand-ultrasonic gesture (HUG), consists of ultrasonic active sensing, pulsed radar signal processing, and time-sequence pattern recognition by machine learning.

2017.7 – 2018.1 **Improving Pedestrian Safety in Urban Cities Using a Wearable Acoustic System**,
Intelligent and Connected Systems Lab, Columbia University, New York, USA,
Advisor: Xiaofan Jiang.
This project aims at using an acoustic wearable system on the headset to detect and localize approaching cars in order to alert the pedestrian of the danger.

2016.5 – 2016.9 **Collaborative Distributed System based on cars/Unmanned Aerial Vehicle Coordinated Formation Design**,
SRT (Students Research Training) program, Tsinghua University, Beijing, China,
Advisor: Yuan Shen.
We developed a multiple robot collaborative localization and navigation system using a self-made mobile robot platform. The robots in our system are equipped with a wireless distributed localization system based on UWB (Ultra Wide Band), which enables them automatically to form a pre-defined formation with mutual localization information.

Student Mentorship

CMU ECE Yuchen Wu (master student), 2021-2022
Gore Kao (master student), 2022-2023
Yiqi Wang (master student), 2022-Present

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.

Selected Professional Services

Review: *Journal:* FoCM, TPAMI.
Conferences: ICLR (2022-2023), ICASSP (2022-2023), ICML (2020-2023), CHIL (2022), NeurIPS (2021-2022), ISIT (2022), ECML(2023).
Workshops: SSP (2021), WiML (2019).
Organization: Breakout session leader at *3rd Women in Machine Learning Un-Workshop, ICML 2022.*

Presentations

Talks

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

2023.6 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