Runyu (Cathy) Zhang

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Education

Harvard University — **Cambridge, MA**
Ph.D. in Applied Mathematics, School of Engineering and Applied Sciences — *Sept. 2019 – Present*
Advisor: Na Li Committee: David Parkes, Jeff Shamma, Bo Dai

Peking University — **Beijing, China**
B.Sc. in Scientific and Engineering Computing — *Sept. 2015 – July 2019*
School of Mathematical Sciences Department

Other Academic Experiences

Salesforce Research — **Palo Alto, CA**
Research Intern — *June 2022 – September 2022*
Advisor: Yu Bai

University of California, Los Angeles — **Los Angeles, CA**
Student Researcher — *June 2018 – September 2018*
Advisor: Deanna Needell

Research Interests

Areas: Reinforcement Learning, Optimal Control, Multi-agent Systems, Distributed Control for Network Systems, Game Theory
Topics: Learning-based Control, Distributed/decentralized control for multi-agent network systems, Multi-agent reinforcement learning, Risk-sensitive/robust reinforcement learning, Online adaptive control.

Awards, Honors, and Scholarships

Rising Star in EECS *2024*
2023 American Control Conference (ACC) Student Travel Award *2023*
Finalist of the Two Sigma Diversity PhD Fellowship (1 of 8) *2022*
Certificates of Distinction and Excellence in Teaching *2020*
Derek Bok Center for Teaching and Learning, Harvard University
Excellent Graduate *2019*
Peking University
Second Prize, China Undergraduate Mathematical Contest in Modeling, Beijing District *2016*
Peking University
Elite Undergraduate Training Program *2016-2019*
School of Mathematical Sciences, Peking University
First Prize in Beijing National High School Student Mathematics Competition *2014*

Job-Related Research Projects

Project 1: Multi-Agent Coverage Control with Transient Behavior Consideration [6]
Role: Main Contributor, First Author
Description: We studied the multi-agent coverage control problem, where a group of agents collectively tasked with efficiently exploring and covering an environment typically characterized by certain density functions,

and proposed an algorithm that achieves sublinear regret even when considering the transient behavior of the agents. The algorithm is also validated through numerical examples and physical multi-drone implementations (see demo video here), which achieves better performance and smaller regret compared with other benchmark algorithms.

Project 2: Cooperative Multi-Agent Graph Bandits [9]
Role: Co-Supervisor
Description: We introduced a novel multi-agent bandit problem with graph structures that captures the essence of various robotics applications, and proposed an upper confidence bound (UCB) algorithm to efficiently solve the problem. Our algorithm is validated on a robotic source-seeking problem (see demo video here).

Project 3: Distributed Learning and Control for Multi-agent Network Systems [12, 4, 8, 5]
Role: Main Contributor, First and Co-First Author
Description: Large network systems often limit agents to local observations due to computational and communication constraints. My work [12] studied spatially exponential decaying systems and showed that the global optimal controller also exhibits a similar spatially decaying structure, meaning each agent can make near-optimal decisions using only its κ-hop neighborhood information. Notably, the work is among the first to establish rigorous optimality gaps for distributed controllers. Building on these foundations, I developed communication-efficient distributed RL algorithms [4, 8] that allow agents to communicate solely with their network neighbors. Recent work [5] extends this to complex nonlinear network dynamics, using novel representations to design scalable, provably efficient algorithms.

Publications

Journal Publications

R. Zhang, W. Li, and N. Li, "On the Optimal Control of Network LQR with Spatially-exponential Decaying Structure," ***Automatica***, 2024.

R. Zhang, Z. Ren, and N. Li, "Gradient Play in Stochastic Games: Stationary Points, Convergence, and Sample Complexity," *IEEE Transactions on Automatic Control* (***TAC***), 2024.

E. X. Chen, X. Han, A. Malkawi, **R. Zhang**, and N. Li, "Adaptive Model Predictive Control with Ensembled Multi-Time Scale Deep-learning Models for Smart Control of Natural Ventilation," *Building and Environment*, 2023.

Y. Li*, Y. Tang*, **R. Zhang**, and N. Li, "Distributed Reinforcement Learning for Decentralized Linear Quadratic Control: A Derivative-Free Policy Optimization Approach," *IEEE Transactions on Automatic Control* (***TAC***), 2022.

Peer-Reviewed Conference Proceedings

Z. Ren*, **R. Zhang***, B. Dai, and N. Li, "Scalable spectral representations for network multiagent control," in ***AISTATS***, 2025.

R. Zhang, H. Ma, and N. Li, "Multi-Agent Coverage Control with Transient Behavior Consideration," in *Learning for Dynamics and Control Conference* (***L4DC***), 2024.

R. Zhang, Y. Hu, and N. Li, "Soft Robust MDPs and Risk-Sensitive MDPs: Equivalence, Policy Gradient, and Sample Complexity," in *International Conference on Learning Representations* (***ICLR***), 2024.

J. Olsson, **R. Zhang**, E. Tegling, and N. Li, "Scalable Reinforcement Learning for Linear-Quadratic Control of Networks," in *American Control Conference* (***ACC***), 2024.

P. Paschalidis, **R. Zhang**, and N. Li, "Cooperative Multi-Agent Graph Bandits: UCB Algorithm and Regret Analysis," in *American Control Conference* (***ACC***), 2024.

R. Zhang, Y. Zhang, R. Konda, B. Ferguson, J. Marden, and N. Li, "Markov Games with Decoupled Dynamics: Price of Anarchy and Sample Complexity," in *the 62nd IEEE Conference on Decision and Control* (***CDC***), 2023.

Y. Zhang, **R. Zhang**, Y. Gu, and N. Li, "Multi-agent Reinforcement Learning with Reward Delays," in *Learning for Dynamics and Control Conference* (***L4DC***), 2024.

R. Zhang, W. Li, and N. Li, "On the Optimal Control of Network LQR with Spatially-exponential Decaying Structure," in *American Control Conference* (***ACC***), 2023.

R. Zhang, Y. Zheng, W. Li, and N. Li, "On the Relationship of Optimal State Feedback and Disturbance Response Controllers," in *the 22nd World Congress of the International Federation of Automatic Control* (***IFAC***), 2023.

R. Zhang*, Q. Liu*, H. Wang, C. Xiong, N. Li, and Y. Bai, "Policy Optimization for Markov Games: Unified Framework and Faster Convergence ," in *Advances in Neural Information Processing Systems* (***NeurIPS***), 2022.

R. Zhang, J. Mei, B. Dai, D. Schuurmans, and N. Li, "On the Global Convergence Rates of Decentralized Softmax Gradient Play in Markov Potential Games ," in *Advances in Neural Information Processing Systems* (***NeurIPS***), 2022.

R. Zhang, Z. Ren, and N. Li, "Gradient Play in Stochastic Games: Stationary Points and Local Geometry ," in *the 25th International Symposium on Mathematical Theory of Networks and Systems* (***MTNS***), 2022.

R. Zhang, Y. Li, and N. Li, "On the Regret Analysis of Online LQR Control with Predictions ," in *American Control Conference* (***ACC***), 2021.

Workshop Papers

M. Gao, J. Haddock, D. Molitor, D. Needell, E. Sadovnik, T. Will, and **R. Zhang**, "Neural Nonnegative Matrix Factorization for Hierarchical Multilayer Topic Modeling ," in *IEEE 8th International Workshop on Computational Advances in Multi-Sensor Adaptive Processing* (*CAMSAP*), 2019.

Pre-Prints and Working Papers

R. Zhang, J. Shamma, and N. Li, "Equilibrium Selection for Multi-agent Reinforcement Learning: A Unified Framework," 2024.

Teaching Experience

ES 202: Learning, Estimation and Control of Dynamical Systems *Spring 2024*
Engineering and Applied Sciences — Harvard University ***Rating: 4.75/5.0***
Section Leader
Led office hours and gave feedback and comments for weekly readings and in-class discussions. Contributed to the design and grading of assignments.

ES155: Systems and Control *Fall 2020*
Engineering and Applied Sciences — Harvard University ***Rating: 4.83/5.0***
Section Leader
Led weekly sections and office hours. Contributed to the design and grading of weekly assignments as well as the midterm and final exams. Gave feedback to 20+ students' course project.

Mentorship

- Johan Olsson (Lund Univerisity, Visiting Master student), 2023
  Project: Distributed reinforcement learning design for networked systems (paper accepted to ACC 2023)
- Phevos Paschalidis, Aryan Naveen (Harvard College), 2023
  Project: Algorithm design for multi-agent graph bandit problem (paper accepted to ACC 2023, preparing journal submission to TAC)

Invited Talks

Equilibrium Selection for Multi-agent Reinforcement Learning: A Unified Framework (*forthcoming*) *2024*
Modeling and Optimization: Theory and Applications (MOPTA), Lehigh University

Robust and Risk-sensitive Sequential Decision-Making in the Face of Model Uncertainty *2024*
CDC workshop on system theory of algorithms, Milan

Multi-Agent Coverage Control with Transient Behavior Consideration (poster, forthcoming) *2024*
Learning for Dynamics and Control Conference(L4DC), Oxford University

Soft Robust MDPs and Risk-Sensitive MDPs: Equivalence, Policy Gradient, and Sample Complexity (poster) *2024*
International Conference on Learning Representations (ICLR), Vienna

Efficient and Resilient Coordination of Multi-agent Systems *2024*
ETH Zurich, MIT, EPFL, Peking University, Tsinghua University

Markov Games with Decoupled Dynamics: Price of Anarchy and Sample Complexity *2023*
Conference on Decision and Control (CDC)

Optimal Control of Spatially Exponential Decaying Linear Quadratic Regulator *2023*
The Institute for Operations Research and the Management Sciences (INFORMS)

Real-time Distributed Coordination of Multiagent Networks under Limited Communication *2023*
ONR Science of Autonomy Program Review

Optimal Control of Spatially Exponential Decaying Linear Quadratic Regulator *2023*
American Control Conference (ACC)

Policy Optimization for Markov Games: Unified Framework and Faster Convergence (Poster) *2022*
Advances in Neural Information Processing Systems (NeurIPS)

On the Global Convergence Rates of Decentralized Softmax Gradient Play in Markov Potential Games (Poster) *2022*
Advances in Neural Information Processing Systems (NeurIPS)

Gradient Play in Stochastic Games: Stationary Points and Local Geometry (Virtual) *2022*
International Symposium on Mathematical Theory of Networks and Systems (MTNS)

On the Effect of log-barrier Regularization in Decentralized Softmax Gradient Play in Multiagent Systems *2022*
International Conference on Continuous Optimization (ICCOPT)

On the Regret Analysis of Online LQR Control with Predictions (Virtual) *2021*
American Control Conference (ACC)

Professional Services

Reviewer for Advances in Neural Information Processing Systems (NeurIPS), Artificial Intelligence and Statistics (AISTATS), IEEE Trans. Automatic Control (TAC), Automatica, IEEE Intelligent Systems, Systems and Control Letters, Dynamic Games and Applications (DGAA), Learning for Dynamics and Control Conference (L4DC), etc.

Guest Speaker and graduate student panelist for Harvard Women in Engineering & CS Event.

Student co-organizer of Harvard Machine Learning Foundations Seminar Series (2022 Fall - 2023 Fall)

Student co-organizer of Harvard-EEML student seminar (2021 Fall - 2022 Spring).

Languages and Skills

Computer Skills: Python, MATLAB, Pytorch, TensorFlow, Simulink
Language: Chinese (native), English (fluent)