Simin Liu

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I'm a PhD candidate at CMU's Robotics Institute. My research combines machine learning and model-based planning and control for structured, scalable autonomy. Recently, I developed a high-performance planner for contact-rich bimanual manipulation, integrating low-level trajectory optimization with high-level graph search. I've also designed safety-enforcing controllers for agile aerial robots, drawing on adversarial learning and formal verification to provide safety guarantees. Previously, I worked on model-based reinforcement learning for millirobot locomotion, enabling adaptation to disturbances and model mismatch.

Education

Carnegie Mellon University   **2020 − 2025**
PhD in Robotics
Thesis: Reachable Sets for Control and Planning: From Reactive Safety to Contact-Rich Manipulation
Advisors: Prof. Changliu Liu, Prof. John Dolan
Selected Coursework: Machine Learning; Convex Optimization; Nonlinear Control; Adaptive Control

University of California, Berkeley   **2015 − 2019**
B.S. Electrical Engineering & Computer Science (High Honors, Dean's List)
Thesis: Adaptive Control for Legged Locomotion via Meta-Learning
Advisors: Prof. Sergey Levine, Prof. Ron Fearing
Minor: Mathematics
Selected Coursework: Graduate Deep Reinforcement Learning

Experience

Research Intern   **09/2024 − 05/2025**
Robotics and AI Institute (formerly Boston Dynamics AI Institute)   *Cambridge, MA*
Developing global planning algorithms for more efficient, scalable contact-rich manipulation.

- Devised a hierarchical planner that integrates contact-aware trajectory optimization, collision-free motion planning, and MIP-based graph search.
- Enabled a bimanual KUKA hardware system to reorient large, unwieldy objects using whole-arm contact, not just end-effectors.
- Achieved >60% lower cost plans than a leading method, producing concise, human-like motion.

Research Assistant   **09/2020 − 12/2025**
Intelligent Control Lab, CMU   *Pittsburgh, PA*
Designing control and planning algorithms for agile aerial systems under state/input constraints.

- Synthesized constraint-enforcing control filters for uncertain systems; generated a collision-avoidance filter for a quadrotor with unknown drag in minutes.
- Combined adversarial ML techniques with nonlinear control to scale control filter synthesis to 10-20D; demonstrated on a quadrotor-pendulum platform, where the filter kept the pendulum upright while the quadrotor tracked a trajectory.
- Built and deployed a quadrotor-pendulum hardware stack; validated simultaneous pendulum balancing and flight stabilization in hardware experiments.
- Improved a lab C++ trajectory-optimization toolbox to attain faster convergence and robustness to infeasible initializations.

∘ Formally verified the robustness of learned perception components in an aircraft autonomy stack.

Research Assistant   **09/2017 – 05/2019**
Robotic AI & Learning Lab, UC Berkeley   *Berkeley, CA*
Investigating learned control techniques for adaptive millirobot locomotion.

∘ Built autonomy stack in ROS2 (wrote microcontroller firmware, integrated mo-cap, camera, and Wi-Fi telemetry) and maintained hardware (diagnosis and repair).
∘ Developed model-based RL pipeline: from offline learning in Tensorflow to online control with MPC.
∘ Using 1.5 hours of data, the learned controller could reject unseen disturbances like leg loss, terrain changes, state-estimation error, and payload variation.

Skills

Programming: Python, C++
Robotics: ROS2, Mujoco, Drake, OpenCV, IPOPT/SNOPT/CVX
ML: PyTorch, TensorFlow
Languages: English, Chinese

Publications

[1] "Approximately Optimal Global Planning for Contact-Rich SE (2) Manipulation on a Graph of Reachable Set." **S. Liu**, T. Zhao, B.P. Graesdal, P. Werner, J. Wang, J. Dolan, C. Liu, T. Pang.
Under review (IEEE T-RO).

[2] "Synthesis and Verification of Robust-Adaptive Safe Controllers." **S. Liu**, K. Yun, J. Dolan, and C. Liu.
In 2024 European Controls Conference.

[3] "Certifying Robustness of Learning-Based Keypoint Detection and Pose Estimation Methods." X. Luo, T. Wei, **S. Liu**, Z. Wang, L. Mattei-Mendez, T. Loper, J. Neighbor, C. Hutchison, and C. Liu.
In 2025 ACM Transactions on Cyber-Physical Systems.

[4] "Safety Index Synthesis via Sum-of-Squares Programming." W. Zhao, T. He, T. Wei, **S. Liu**, and C. Liu.
In 2023 American Controls Conference.

[5] "Learning the positions in countsketch." Y. Li, H. Lin, **S. Liu**, A. Vakilian, D.P. Woodruff.
In 2023 International Conference in Learning Representations. **Oral presentation, top 25%.**

[6] "Safe Control Under Input Limits with Neural Control Barrier Functions." **S. Liu**, C. Liu, and J. Dolan.
In 2022 Conference on Robot Learning.

[7] "On learned sketches for randomized numerical linear algebra." **S. Liu**, T. Liu, A. Vakilian, Y. Wan, DP Woodruff.
arXiv preprint arXiv:2007.09890_ (2020).

[8] "Learning to Adapt in Dynamic, Real-World Environments Through Meta-Reinforcement Learning." A. Nagabandi*, I. Clavera*, **S. Liu**, R. S. Fearing, P. Abbeel, S. Levine, and C. Finn.
In 2018 International Conference on Learning Representations.

Honors and Awards

∘ Qualcomm Graduate Fellowship: 18 selected from 182   **2023**
∘ UC Berkeley Undergraduate Research Honors: 20 selected from 500   **2019**

- Computing Research Association GHC Research Scholars **2018**
- Microsoft Undergraduate GHC Scholarship **2017**
- Top 10% of TAs in UC Berkeley EECS Department **2017–2018**
- UC Berkeley College of Engineering Dean's List: top 10% highest GPAs **2016–19**
- Tau Beta Pi, Eta Kappa Nu, and Phi Beta Kappa: **2016**
  National engineering, computer science, liberal arts honor societies
- William Olson Science and Engineering Undergraduate Scholarship **2015**
- ACES Asian-American Undergraduate Scholarship **2015**

Talks

- "Global Planning for Contact-Rich Manipulation", Manipulation Seminar, CMU **2026**
- "Reactive Safety for Self-Driving", Qualcomm Graduate Fellowship awardee talks **2024**
- "Synthesis of Safe Control Filters for Uncertain Systems", European Controls Conference (ECC) **2024**
- "Scalable Synthesis of Safe Control Filters", Conference on Robot Learning (CORL) **2021**
- "Scalable Synthesis of Safe Control Filters", Safe Autonomous Systems Lab, UCSD **2021**
- "Sample Inefficiency in Deep-Reinforcement Learning for Robotics", Women in Machine Learning Workshop, ICML **2020**

Teaching

- CMU 16-711 (Kinematics, Dynamics, and Control), taught by Hartmut Geyer **Fall 2022**
- CMU 16-811 (Math Fundamentals for Robotics), taught by Michael Erdmann **Fall 2021**
- UC Berkeley CS188 (Introduction to Artificial Intelligence), taught by Sergey Levine **Spring 2019**
- UC Berkeley CS170 (Efficient Algorithms and Intractable Problems), **Fall 2017-2018**
  Taught by Umesh Vazirani, Prasad Raghavendra, Sanjam Garge

Service

Mentoring

- Yogita Choudhary, CMU MS to CMU PhD
- Chase Dunaway, New Mexico Tech BS to CMU PhD
- Dvij Kalaria, CMU MS to UC Berkeley PhD
- Shivesh Khaitan, CMU MS to ML Engineer at Aurora
- Haoru Xue, CMU MS to UC Berkeley PhD
- Kai Yun, CMU MS to MIT PhD

Academic Reviewer

- Robotics: T-RO, R-AL, ICRA, IROS
- Controls: ACC
- Machine Learning: L4DC, ICLR