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Stephen Tu

research interests

I study problems at the intersection of machine learning, optimization, and control theory. My recent work focuses on developing a principled understanding of using machine learning models for data-driven control, with specific emphasis on applications in robotics.

education

Ph.D., EECS, University of California, Berkeley. Spring 2019.
Advised by Prof. Benjamin Recht.
Thesis: Sample Complexity Bounds for the Linear Quadratic Regulator.

S.M., EECS, Massachusetts Institute of Technology. Spring 2013.
Advised by Prof. Samuel Madden.
Thesis: Fast Transactions for Multicore In-Memory Databases.

B.A., Computer Science, University of California, Berkeley. Fall 2010.
B.S., Mechanical Engineering, University of California, Berkeley. Fall 2010.

positions

Assistant Professor. University of Southern California. 1/2024–Present.
Ming Hsieh Department of Electrical and Computer (ECE) Engineering.

Research Scientist. Google DeepMind Robotics. 9/2019–12/2023.

preprints

Shallow diffusion networks provably learn hidden low-dimensional structure. arXiv, 2024.
Nicholas M. Boffi, Arthur Jacot, Stephen Tu, and Ingvar Ziemann.

Incremental Composition of Learned Control Barrier Functions in Unknown Environments. arXiv, 2024.
Paul Lutkus, Deepika Anantharaman, Stephen Tu, and Lars Lindemann.

journal articles

Safely Learning Dynamical Systems. Accepted to FoCM, 2024.
Amir Ali Ahmadi, Abraar Chaudhry, Vikas Sindhwani, and Stephen Tu.

Revisiting Energy Based Models as Policies: Ranking Noise Contrastive Estimation and Interpolating Energy Models. TMLR, 2024.
Sumeet Singh, Stephen Tu, and Vikas Sindhwani.

Learning from many trajectories. JMLR, Vol. 25, No. 216, 2024.
Stephen Tu, Roy Frostig, and Mahdi Soltanolkotabi.

Learning Robust Output Control Barrier Functions from Safe Expert Demonstrations. IEEE Open Journal of Control Systems, Vol. 3. 2024.
Lars Lindemann, Alexander Robey, Lejun Jiang, Satyajeet Das, Stephen Tu, and Nikolai Matni.

Nonparametric adaptive control and prediction: theory and randomized algorithms. JMLR, Vol. 23, No. 281, 2022.
Nicholas M. Boffi, Stephen Tu, and Jean-Jacques E. Slotine.

On the Sample Complexity of the Linear Quadratic Regulator. FoCM, Vol. 20, No. 4, 2020.
Sarah Dean, Horia Mania, Nikolai Matni, Benjamin Recht, and Stephen Tu.

conference papers

Stability properties of gradient flow dynamics for the symmetric low-rank matrix factorization problem. ACC 2025.
Hesameddin Mohammadi, Mohammad Tinati, Stephen Tu, Mahdi Soltanolkotabi, and Mihailo R. Jovanović

Sharp Rates in Dependent Learning Theory: Avoiding Sample Size Deflation for the Square Loss. ICML 2024 (spotlight).
Ingvar Ziemann, Stephen Tu, George J. Pappas, and Nikolai Matni.

The noise level in linear regression with dependent data. NeurIPS 2023.
Ingvar Ziemann, Stephen Tu, George J. Pappas, and Nikolai Matni.

Robots That Ask For Help: Uncertainty Alignment for Large Language Model Planners. CoRL 2023.
Allen Z. Ren, Anushri Dixit, Alexandra Bodrova, Sumeet Singh, Stephen Tu, Noah Brown, Peng Xu, Leila Takayama, Fei Xia, Jake Varley, Zhenjia Xu, Dorsa Sadigh, Andy Zeng, and Anirudha Majumdar.

Bootstrapped Representations in Reinforcement Learning. ICML 2023.
Charline Le Lan, Stephen Tu, Mark Rowland, Anna Harutyunyan, Rishabh Agarwal, Marc G. Bellemare, and Will Dabney.

The Power of Learned Locally Linear Models for Nonlinear Policy Optimization. ICML 2023.
Daniel Pfrommer, Max Simchowitz, Tyler Westenbroek, Nikolai Matni, and Stephen Tu.

Agile Catching with Whole-Body MPC and Blackbox Policy Learning. L4DC 2023.
Saminda Abeyruwan, Alex Bewley, Nicholas M. Boffi, Krzysztof Choromanski, David D'Ambrosio, Deepali Jain, Pannag Sanketi, Anish Shankar, Vikas Sindhwani, Sumeet Singh, Jean-Jacques Slotine, and Stephen Tu.

Multi-Task Imitation Learning for Linear Dynamical Systems. L4DC 2023.
Thomas T. Zhang, Katie Kang, Bruce D. Lee, Claire Tomlin, Sergey Levine, Stephen Tu, and Nikolai Matni.

Visual Backtracking Teleoperation: A Data Collection Protocol for Offline Image-Based Reinforcement Learning. ICRA 2023.
David Brandfonbrener, Stephen Tu, Avi Singh, Stefan Welker, Chad Boodoo, Nikolai Matni, and Jake Varley.

Learning Model Predictive Controllers with Real-Time Attention for Real-World Navigation. CoRL 2022.
Xuesu Xiao, Tingnan Zhang, Krzysztof Choromanski, Edward Lee, Anthony Francis, Jake Varley, Stephen Tu, Sumeet Singh, Peng Xu, Fei Xia, Sven Mikael Persson, Dmitry Kalashnikov, Leila Takayama, Roy Frostig, Jie Tan, Carolina Parada, and Vikas Sindhwani.

Learning with little mixing. NeurIPS 2022.
Ingvar Ziemann and Stephen Tu.

TaSIL: Taylor Series Imitation Learning. NeurIPS 2022.
Daniel Pfrommer, Thomas T.C.K. Zhang, Stephen Tu, and Nikolai Matni.

Adversarially Robust Stability Certificates can be Sample-Efficient. L4DC 2022.
Thomas T.C.K. Zhang, Stephen Tu, Nicholas M. Boffi, Jean-Jacques E. Slotine, and Nikolai Matni.

On the Sample Complexity of Stability Constrained Imitation Learning. L4DC 2022.
Stephen Tu, Alexander Robey, Tingnan Zhang, and Nikolai Matni.

The role of optimization geometry in single neuron learning. AISTATS 2022.
Nicholas M. Boffi, Stephen Tu, and Jean-Jacques E. Slotine.

On the Generalization of Representations in Reinforcement Learning. AISTATS 2022.
Charline Le Lan, Stephen Tu, Adam Oberman, Rishabh Agarwal, and Marc G. Bellemare.

Learning Robust Hybrid Control Barrier Functions for Uncertain Systems. ADHS 2021.
Alexander Robey, Lars Lindemann, Stephen Tu, and Nikolai Matni.

Regret Bounds for Adaptive Nonlinear Control. L4DC 2021.
Nicholas M. Boffi*, Stephen Tu*, and Jean-Jacques E. Slotine. (* equal contribution.)

Safely Learning Dynamical Systems from Short Trajectories. L4DC 2021.
Amir Ali Ahmadi, Abraar Chaudhry, Vikas Sindhwani, and Stephen Tu.

Learning Hybrid Control Barrier Functions from Data. CoRL 2020.
Lars Lindemann, Haimin Hu, Alexander Robey, Hanwen Zhang, Dimos V. Dimarogonas, Stephen Tu, and Nikolai Matni.

Learning Stability Certificates from Data. CoRL 2020.
Nicholas M. Boffi*, Stephen Tu*, Nikolai Matni, Jean-Jacques E. Slotine, and Vikas Sindhwani. (* equal contribution.)

Learning Control Barrier Functions from Expert Demonstrations. CDC 2020.
Alexander Robey, Haimin Hu, Lars Lindemann, Hanwen Zhang, Dimos V. Dimarogonas, Stephen Tu, and Nikolai Matni.

Observational Overfitting in Reinforcement Learning. ICLR 2020.
Xingyou Song, Yiding Jiang, Stephen Tu, Yilun Du, and Behnam Neyshabur.

From Self-Tuning Regulators to Reinforcement Learning and Back Again. CDC 2019.
Nikolai Matni, Alexandre Proutiere, Anders Rantzer, and Stephen Tu

A Tutorial on Concentration Bounds for System Identification. CDC 2019.
Nikolai Matni and Stephen Tu

Finite-time Analysis of Approximate Policy Iteration for the Linear Quadratic Regulator. NeurIPS 2019.
Karl Krauth*, Stephen Tu*, and Benjamin Recht. (* equal contribution.)

Certainty Equivalence is Efficient for Linear Quadratic Control. NeurIPS 2019.
Horia Mania, Stephen Tu, and Benjamin Recht.

The Gap Between Model-Based and Model-Free Methods on the Linear Quadratic Regulator: An Asymptotic Viewpoint. COLT 2019.
Stephen Tu and Benjamin Recht.

Minimax Lower Bounds for $\mathcal{H}_\infty$-Norm Estimation. ACC 2019.
Stephen Tu*, Ross Boczar*, and Benjamin Recht. (* equal contribution.)

Safely Learning to Control the Constrained Linear Quadratic Regulator. ACC 2019.
Sarah Dean, Stephen Tu, Nikolai Matni, and Benjamin Recht.

Regret Bounds for Robust Adaptive Control of the Linear Quadratic Regulator. NeurIPS 2018.
Sarah Dean, Horia Mania, Nikolai Matni, Benjamin Recht, and Stephen Tu.

Least-Squares Temporal Difference Learning for the Linear Quadratic Regulator. ICML 2018.
Stephen Tu and Benjamin Recht.

Learning Without Mixing: Towards A Sharp Analysis of Linear System Identification. COLT 2018.
Max Simchowitz, Horia Mania, Stephen Tu, Michael I. Jordan, and Benjamin Recht.

On the Approximation of Toeplitz Operators for Nonparametric $\mathcal{H}_\infty$-norm Estimation. ACC 2018.
Stephen Tu, Ross Boczar, and Benjamin Recht.

Breaking Locality Accelerates Block Gauss-Seidel. ICML 2017.
Stephen Tu, Shivaram Venkataraman, Ashia C. Wilson, Alex Gittens, Michael I. Jordan, and Benjamin Recht.

Cyclades: Conflict-free Asynchronous Machine Learning. NeurIPS 2016.
Xinghao Pan, Maximilian Lam, Stephen Tu, Dimitris Papailiopoulos, Ce Zhang, Michael I. Jordan, Kannan Ramchandran, Christopher Ré, and Benjamin Recht.

Low-rank Solutions of Linear Matrix Equations via Procrustes Flow. ICML 2016.
Stephen Tu, Ross Boczar, Max Simchowitz, Mahdi Soltanolkotabi, and Benjamin Recht.

Machine Learning Classification over Encrypted Data. NDSS 2015.
Raphael Bost, Raluca Ada Popa, Stephen Tu, and Shafi Goldwasser.

Fast Databases with Fast Durability and Recovery through Multicore Parallelism. OSDI 2014.
Wenting Zheng, Stephen Tu, Eddie Kohler, and Barbara Liskov.

Anti-Caching: A New Approach to Swapping in Main Memory OLTP Database Systems. VLDB 2014.
Justin DeBrabant, Andrew Pavlo, Stephen Tu, Michael Stonebraker, and Stan Zdonik.

Speedy Transactions in Multicore In-Memory Databases. SOSP 2013.
Stephen Tu, Wenting Zheng, Eddie Kohler, Barbara Liskov, and Samuel Madden.

Processing Analytical Queries over Encrypted Data. VLDB 2013.
Stephen Tu, M. Frans Kaashoek, Samuel Madden, and Nickolai Zeldovich.

The HipHop Compiler for PHP. OOPSLA 2012.
Haiping Zhao, Iain Proctor, Minghui Yang, Xin Qi, Mark Williams, Guilherme Ottoni, Charlie Gao, Andrew Paroski, Scott MacVicar, Jason Evans, and Stephen Tu.

The Case for PIQL: A Performance Insightful Query Language. SoCC 2010.
Michael Armbrust, Nick Lanham, Stephen Tu, Armando Fox, Michael Franklin, and David Patterson.

PIQL: A Performance Insightful Query Language For Interactive Applications. SIGMOD 2010 Demo.
Michael Armbrust, Stephen Tu, Armando Fox, Michael Franklin, David Patterson, Nick Lanham, Beth Trushkowsky, and Jesse Trutna.

industry experience

Research Scientist. Robotics at Google. 9/2019–12/2023.
Research learning to control applications in robotics.
Open sourced and maintain trajax, a differentiable optimal control library: https://github.com/google/trajax.
Manager: Vikas Sindhwani.

Software Engineering Intern. Google Brain. Summer 2017.
Worked on projects related to trajectory optimization and learning Lyapunov functions from data.
Hosted by Vikas Sindhwani.

Developer. Data-microscopes team, Qadium. Summer 2014.
Wrote the first implementation of `data-microscopes`, a Bayesian non-parametric library for Python.
Project page: https://datamicroscopes.github.io/

Software Engineering Intern. HPHP team, Facebook. 4/2011–8/2011.
Implemented various performance improvements in Facebook's PHP source-to-source translator.

Software Engineering Intern. Datacenters team, Facebook. 1/2011–4/2011.
Worked on deploying a row level consistency checker for Facebook's distributed MySQL deployment.

Software Engineering Intern. Intuit. Summer 2009.
Built tools for encoding tax specifications in XPath.

teaching

EE 660–Mathematical Foundations of Machine Learning, University of Southern California. Fall 2024.

EE 660–Mathematical Foundations of Machine Learning, University of Southern California. Spring 2024.

Graduate Student Instructor. CS 189–Introduction to Machine Learning, UC Berkeley. Fall 2018.

Graduate Student Instructor. CS 189–Introduction to Machine Learning, UC Berkeley. Fall 2016.

service L4DC Program Chair (2025).
NeurIPS Area Chair (2021).
Reviewer for OSDI, NeurIPS, ICML, ACC, CDC, AISTATS, COLT, CoRL, L4DC, and JMLR.
2022: Mentor for Google's CS Research Mentorship Program.