Haihao (Sean) Lu

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Research Interests

Large-scale optimization, machine learning and data-driven decision making.

Appointment

Massachusetts Institute of Technology, Cambridge, MA — July 2024-present
Sloan School of Management
Assistant Professor

University of Chicago, Chicago, IL — July 2020-June 2024
Booth School of Business
Assistant Professor of Operations Management

Google Research, New York City, NY
Visiting Faculty Researcher — July 2019-June 2020
Large-Scale Optimization Team
Manager: Vahab Mirrokni

Education

Massachusetts Institute of Technology, Cambridge, MA — 2014-2019
Ph.D. in Mathematics & Operations Research,
Thesis Title: Large-Scale Optimization Methods for Data-Science Applications
Advisor: Prof. Robert M. Freund
Thesis Committee Members: Robert M. Freund, Rahul Mazumder, Ankur Moitra, Jonathan Kelner

Shanghai Jiao Tong University, Shanghai, China — 2010-2014
B.S. in Applied Mathematics, Zhiyuan College, Graduation with distinction
Advisor: Prof. David Cai

Selected Honors

INFORMS Revenue Management and Pricing Section Prize (link). 2023
This prize is awarded for the best contribution to the science of pricing and revenue management published in English.

Michael H. Rothkopf Junior Researcher Paper Prize (first place) (link). 2022
This prize recognizes the best paper by a young researcher in the area of Auctions and Market Design.

Special invited session on "spotlight beyond WINE" (link). 2022
This session at WINE highlights some of the best works in algorithmic game theory that appeared in conferences and journals other than WINE, or mature working papers.

INFORMS Optimization Society Young Researcher Prize (link). 2021
This prize serves as an esteemed recognition of promising colleagues in the field of optimization who are at the beginning of their academic or industrial career.

Reitano Fellowship 2014-2015
This fellowship recognizes research excellence for incoming students at MIT Mathematics Department.

Journal Publications

"On the Geometry and Refined Rate of Primal-Dual Hybrid Gradient for Linear Programming", with Jinwen Yang, to appear at *Mathematical Programming*.

"Infeasibility Detection with Primal-Dual Hybrid Gradient for Large-Scale Linear Programming", with David Applegate, Mateo Diaz and Miles Lubin, *SIAM Journal on Optimization* 34.1 (2024): 459-484.

"On the Linear Convergence of Extra-Gradient Methods for Nonconvex-Nonconcave Minimax Problems", Saeed Hajizadeh, Haihao Lu and Benjamin Grimmer, *INFORMS Journal on Optimization* 6.1 (2024): 19-31.

"A J-Symmetric Quasi-Newton Method for Minimax Problems", with Azam Asl and Jinwen Yang, *Mathematical Programming* 204.1 (2024): 207-254.

"The Landscape of Nonconvex-Nonconcave Minimax Optimization", Benjamin Grimmer, Haihao Lu, Pratik Worah and Vahab Mirrokni, *Mathematical Programming* 201.1-2 (2023): 373-407.

"Faster First-Order Primal-Dual Methods for Linear Programming using Restarts and Sharpness", with David Applegate, Oliver Hinder and Miles Lubin, *Mathematical Programming* 201.1-2 (2023): 133-184.

"Frank-Wolfe Methods with an Unbounded Feasible Region and Applications to Structured Learning", Haoyue Wang, Haihao Lu and Rahul Mazumder, *SIAM Journal on Optimization* 32.4 (2022): 2938-2968.

"The Best of Many Worlds: Dual Mirror Descent for Online Allocation Problems", with Santiago Balseiro and Vahab Mirrokni, *Operations Research* 71.1 (2022): 101-119.

"An $O(s^r)$-Resolution ODE Framework for Discrete-Time Optimization Algorithms and Applications to the Linear Convergence of Minimax Problems", Haihao Lu, *Mathematical Programming* 194 (2022): 1061–1112.

"Randomized Gradient Boosting Machines", Haihao Lu and Rahul Mazumder, *SIAM Journal on Optimization* 2020, 30(4), 2780-2808.

"Generalized Stochastic Frank-Wolfe Algorithm with Stochastic 'Substitute' Gradient for Structured Convex Optimization", Haihao Lu and Robert M. Freund, *Mathematical Programming* 187.1 (2021): 317-349.

" 'Relative-Continuity' for Non-Lipschitz Non-Smooth Convex Optimization using Stochastic (or Deterministic) Mirror Descent", Haihao Lu, *INFORMS Journal on Optimization*, 2019, 1(4): 288-303.

"Relatively-Smooth Convex Optimization by First-Order Methods, and Applications", Haihao Lu, Robert M. Freund and Yurii Nesterov, *SIAM Journal on Optimization*, 2018, 28(1): 333-354.

"New Computational Guarantees for Solving Convex Optimization Problems with First Order Methods, via a Function Growth Condition Measure", Robert M. Freund, Haihao Lu, *Mathematical Programming* 2018, Vol.170, No.2: 445-477.

"Stochastic Linearization of β-Fermi-Pasta-Ulam Dynamics in Equilibrium and Non-equilibrium State", Shi-xiao W. Jiang, Haihao Lu, Douglas Zhou, and David Cai, *New Journal of Physics*, 2016, 18(8): 083028.

"Renormalized Dispersion Relations of β-Fermi-Pasta-Ulam Chains in Equilibrium and Nonequilibrium states", Shi-xiao W. Jiang, Haihao Lu, Douglas Zhou, and David Cai. *Physical Review E*, 2014, 90(3): 032925.

Refereed Conference Publications

"A Field Guide for Pacing Budget and ROS Constraints", with Santiago Balseiro, Kshipra Bhawalkar, Zhe Feng, Vahab Mirrokni, Balasubramanian Sivan and Di Wang, *ICML 2024*.

"Online Ad Procurement in Non-stationary Autobidding Worlds", with Jason Liang and Baoyu Zhou, *NeurIPS 2023*.

"Limiting Behaviors of Nonconvex-Nonconcave Minimax Optimization via Continuous-Time Systems", Benjamin Grimmer, Haihao Lu, Pratik Worah and Vahab Mirrokni, *ALT 2022*.

"Practical Large-Scale Linear Programming using Primal-Dual Hybrid Gradient", with David Applegate, Oliver Hinder, Mateo Diaz, Miles Lubin, Brendan O'Donoghue, and Warren Schudy, *NeurIPS 2021*.

"Regularized Online Allocation Problems: Fairness and Beyond", with Santiago Balseiro and Vahab Mirrokni, *ICML* 2021.

"Contextual Reserve Price Optimization in Auctions", Joey Huchette, Haihao Lu, Hossein Esfandiari and Vahab Mirrokni, *NeurIPS*, 2020.

"Dual Mirror Descent for Online Allocation Problems", with Santiago Balseiro and Vahab Mirrokni, *ICML*, 2020.

"Accelerating Gradient Boosting Machines", Haihao Lu, Sai Praneeth Karimireddy, Natalia Ponomareva and Vahab Mirrokni, *AISTATS*, 2020.

"A Stochastic First-Order Method for Ordered Empirical Risk Minimization", Kenji Kawaguchi and Haihao Lu, *AISTATS*, 2020.

"Accelerating Greedy Coordinate Descent Methods", Haihao Lu, Robert M. Freund and Vahab Mirrokni, *ICML*, 2018.

"Approximate Leave-One-Out for Fast Parameter Tuning in High Dimensions", Shuaiwen Wang, Wenda Zhou, Haihao Lu, Arian Maleki, Vahab Mirrokni, *ICML*, 2018.

Preprints and Papers under Reviews

"Achieving Fairness and Accuracy in Regressive Property Taxation", with Feiyu Han and Ozan Candogan.

"Optimizing Scalable Targeted Marketing Policies with Constraints", with Duncan Simester and Yuting Zhu.

"cuPDLP. jl: A GPU Implementation of Restarted Primal-Dual Hybrid Gradient for Linear Programming in Julia", with Jinwen Yang.

"A Practical and Optimal First-Order Method for Large-Scale Convex Quadratic Programming", with Jinwen Yang.

"On the Convergence of L-shaped Algorithms for Two-Stage Stochastic Programming", with John Birge and Baoyu Zhou.

"On the Infimal Sub-differential Size of Primal-Dual Hybrid Gradient Method", with Jinwen Yang.

"On the Sparsity of Optimal Linear Decision Rules in Robust Inventory Management", with Bradley Sturt.

"On a Unified and Simplified Proof for the Ergodic Convergence Rates of PPM, PDHG and ADMM", with Jinwen Yang.

"Analysis of Dual-Based PID Controllers through Convolutional Mirror Descent", with Santiago Balseiro, Vahab Mirrokni and Balasubramanian Sivan.

"Regularized Online Allocation Problems: Fairness and Beyond", with Santiago Balseiro and Vahab Mirrokni.

"Nearly Optimal Linear Convergence of Stochastic Primal-Dual Methods for Linear Programming", with Jinwen Yang.

"Approximate Leave-One-Out for High-Dimensional Non-Differentiable Learning Problems", Shuaiwen Wang, Wenda Zhou, Arian Maleki, Haihao Lu and Vahab Mirrokni.

Technical Reports

"Depth Creates No Bad Local Minima", Haihao Lu and Kenji Kawaguchi, *Technical Report*.

Past Industry Experience

Google Research, Cambridge, MA — Oct 2018-April 2019
Student Researcher
Mentor: Miles Lubin, Natalia Ponomareva
Expanding the project on the huge-scale Linear Programming solver. Developing and implementing the Accelerated Gradient Boosting Machine with CART trees.

Google Research, New York City, NY — Summer 2018
Research Intern
Mentor: Miles Lubin, David Applegate
Designed and implemented a huge-scale Linear Programming solver using first-order methods. The solver was able to solve a Linear Programming problem with multi-billion non-zeros on a single machine, and could be implemented distributedly across thousands of machines.

Google Inc, New York City, NY — Summer 2017
Software Engineer Intern
Mentor: Vahab Mirrokni, Vineet Kahlon
Developed new machine learning models for reserve price optimization of display ads, which gained a 2.7% revenue lift compared with the production model. The models were put on production in 2018Q2.

IBM T.J.Watson Research Center, Yorktown Heights, NY — Summer 2016
Research Intern
Mentor: Andrew Conn
Developed new distributed optimization methods to solve deep learning problems, conducted extensive computational testing on preliminary tasks.

Teaching Experience and Evaluation

Booth School of Business, University of Chicago:[1]
Instructor

- BUSN 32100 Data Analysis with R and Python (MBA)
  - Section 32100-02 (Full-Time MBA): 5.0, 4.3, 5.0, 4.8, 5.0. — Spring 2021
  - Section 32100-01 (Full-Time MBA): 4.7, 4.5, 4.7, 4.3, 4.5. — Spring 2022

[1] Five evaluation questions (out of 5): "Did the instructor convey the course material clearly," "Did the instructor convey the material in an interesting way," "Did you take away useful tools, concepts, and/or insights from this course," "How much did you get out of this course," and "Would you recommend this course to other students."

  - Section 32100-81 (Evening MBA): 4.8, 4.7, 4.9, 4.6, 4.8. Spring 2022
  - Section 32100-01 (Full-Time MBA): 4.8, 4.7, 4.7, 4.5, 4.7. Spring 2023
  - Section 32100-02 (Full-Time MBA): 4.9, 4.7, 4.8, 4.7, 4.7. Spring 2023
- BUSN 36919 Modern Large-Scale Optimization: Theory and Computation (PhD)
  - Section 36919-50: 4.8, 4.5, 5.0, 4.5, 4.5. Spring 2023

Presentations

GPU-Based First-Order Methods for Linear Programming and Beyond

- Industrial Engineering and Management Sciences, Northwestern University, May 2024
- Industrial and Systems Engineering, University of Minnesota, May 2024

A Practical and Optimal First-Order Method for Large-Scale Convex Quadratic Programming

- INOFMRS Conference on Optimization, Houston, March 2024

First-Order Methods for Constrained Continuous Optimization

- Operations Research Center, MIT, December 2023
- DRO and IEOR joint seminar, Columbia University, November 2023
- Viterbi School of Engineering, University of Southern California, November 2023
- School of Data Science, Chinese University of Hong Kong, October 2023

First-Order Methods for Linear Programming: Theory, Computation and Applications

- INFORMS Annual Meeting, October 2023
- SIAM Conference on Optimization, May 2023
- Shanghai University of Finance and Economics, March 2023
- INFORMS Annual Conference, October 2022
- Argonne National Lab, IL, September 2022
- Applied Mathematics Department, John Hopkins University, September 2022
- School of Operations Research and Information Engineering, Cornell University, August 2022
- Operations Research Center, MIT, IL, March 2022
- Institute for Interdisciplinary Information Sciences (Yao's class), Tsinghua University, February 2022
- Booth School of Business, University of Chicago, November 2021
- Tepper School of Business, Carnegie Mellon University, September 2021

The Best of Many Worlds: Dual Mirror Descent for Online Allocation Problems

- INFORMS Annual Conference, IN, October 2022
- Simons Institute for the Theory of Computing, October 2022
- Institute for Data, Systems, and Society, MIT, December 2021
- Stern School of Business, New York University, October 2021
- Liautaud Graduate School of Business, University of Illinois at Chicago, March 2021
- Ebay Inc, August, 2020
- Google Research NYC, June 2020

Accelerated Gradient Boosting Machines

- International Conference on Artificial Intelligence and Statistics, August 2020

An $O(s^r)$-Resolution ODE Framework for Discrete-Time Optimization Algorithms and Applications to Minimax Problems

- Chinese Academy of Sciences, December 2020
- AI+Math Colloquia, Shanghai Jiao Tong University, November 2020

- INFORMS Annual Meeting, November 2020
- Google Research NYC, June 2020
- SIAM Conference on Mathematics of Data Science, June 2020

Ordered-SGD: A New Stochastic Optimization Framework for Empirical Risk Minimization

- International Conference on Artificial Intelligence and Statistics, August 2020
- International Conference on Continuous Optimization, Berlin, August 2019
- Google Research, New York City, Sep 2019
- Rensselaer Polytechnic Institute, Mathematics Department, Nov 2019
- NYU, Courant Institute of Mathematical Science, Nov 2019

Gradient Boosting Machines: New Insights, Algorithms, and Improved Complexity

- National University of Singapore, ISEM, January 2019
- University of Toronto, Mathematics and Computer Science, January 2019
- University of Toronto, MIE, January 2019
- University of Chicago, Booth, January 2019
- University of Minnesota, Twin Cities, ISE, January 2019
- Duke University, Mathematics and Computer Science, January 2019
- Columbia University, IEOR, February 2019
- University of Wisconsin, Madison, ISE, February 2019
- University of Illinois, Urbana-Champaign, ISE, February 2019
- Google Research, Cambridge, February 2019
- Google Research, New York City, March 2019

Randomized Gradient Boosting Machines

- INFORMS Annual Meeting, Phoenix, November 2018

Scalable Linear Programming via First-Order Methods

- Princeton Optimization Day (Poster), Princeton, September 2018
- Google Research, New York City, August 2018

Generalized Stochastic Frank-Wolfe Algorithm with Stochastic 'Substitute' Gradient for Structured Convex Optimization

- Columbia University, Statistics Department, August 2018
- International Symposium on Mathematical Programming (ISMP), Bordeaux, July 2018

Accelerating Greedy Coordinate Descent Methods

- Google Research, New York City, July 2018
- International Conference on Machine Learning, Stockholm, July 2018
- NYAS Meeting on Machine Learning (Poster), New York City, March 2018

Approximate Leave-One-Out for Fast Parameter Tuning in High Dimensions

- International Conference on Machine Learning (Poster), Stockholm, July 2018
- NYAS Meeting on Machine Learning (Poster), New York City, March 2018

"Relative-Continuity" for Non-Lipschitz Non-Smooth Convex Optimization using Stochastic (or Deterministic) Mirror Descent

- INFORMS Meeting on Optimization, Denver, March 2018
- INFORMS Annual Meeting, Houston, Oct 2017

Relatively-Smooth Convex Optimization by First-Order Methods, and Applications

- SIAM Conference on Optimization, Vancouver, May 2017
- INFORMS Annual Meeting, Nashville, November 2016

Extending the Scope of 'Smooth' and 'Non-Smooth' Convex Optimization via First-Order Methods

- University of Edinburgh, Edinburgh, UK, April 2016

Some New Results for Randomized Coordinate Gradient Descent

- International Symposium on Mathematical Programming (ISMP), Pittsburg, July 2015

Academic Service

Community Service and Conference/Workshop Organizer

- Vice chair of linear and conic optimization for INFORMS Optimization Society (2023-now)
- Program committee for INFORMS Optimization Society Conference (2024)
- Organizer of the workshop on modern continuous optimization at MIT (2023)
- Judge: George Nicholson student paper competition (2023)

University Committee Service

- Chicago Booth OM Faculty Recruiting Subcommittee Member 2022-2023
- Chicago Booth OM Workshop Co-Organizer 2021-2022

Reviewer for Journals and Conferences:
Mathematical Programming, *SIAM Journal on Optimization*, *Mathematics of Operations Research*,*Foundations of Computational Mathematics*, *Operations Research*, *Management Science*, *Manufacturing & Service Operations Management*, *Production and Operations Management*, *Journal of Machine Learning Research* (**editorial board**), *IEEE Transactions on Image Processing*, *Computational Optimization and Applications*, *INFORMS Journal on Optimization*, *Machine Learning*, *Journal of Optimization Theory and Applications*, *NeurIPS*, *WebConf*, *ICML*.

Miscellaneous

Computing: Python, Julia, C++, R
Hobbies: Food/Cuisine, Kayaking, Sailing, Hiking, Skiing