Samy Wu Fung

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Appointments

- Assistant Professor. Department of Applied Mathematics and Statistics. Colorado School of Mines. August 2021 - present
- Assistant Adjunct Professor. Department of Mathematics, University of California, Los Angeles. July 2019 - August 2021
- Givens Associate. MCS Division, Argonne National Laboratory. May 15, 2018 - Nov 30, 2018

Education

- PhD. in Applied Mathematics, Emory University, Atlanta, GA, May 2019
  Advisor: Lars Ruthotto
- BSc. in Applied Mathematics, Brown University, Providence, RI, May 2014
  Advisor: Johnny Guzmán
- AA. in Mathematics, Miami Dade College, Miami, FL, May 2011

Research Interests

- Inverse Problems, Deep Learning, Optimization, Optimal Control, Mean Field Games

Preprints/Submitted Articles

1. Ivanitskiy, MI, Shah R, Spies AF, Räuker T, Valentine D, Rager C, Quirke L, Mathwin C, Corlouer G, Diniz-Behn C, Wu Fung S. A Configurable Library for Generating and Manipulating Maze Datasets. arXiv:2309.10498, 2023.
2. McKenzie D, Wu Fung S, Heaton H, Yin W. Faster Predict-and-Optimize with Three-Operator Splitting, arXiv:2301.13395, 2023.
3. Heaton H, McKenzie D, Li Q, Wu Fung S, Osher S, Yin W. Learn to Predict Equilibra via Fixed Point Networks, arXiv:2106.00906, 2021

Published/Accepted Articles

1. Ivanitskiy, MI, Spies AF, Räuker T, Corlouer G, Mathwin C, Quirke L, Rager C, Shah R, Valentine D, Diniz-Behn C, Katsumi I, Wu Fung S. Structured World Representations in

Maze-Solving Transformers. *NeurIPS Workshop on Unifying Representations in Neural Models*, 2023.

2. Heaton H*, Wu Fung S*. Explainable AI via Learning to Optimize, *Scientific Reports*, 13 (10103), 2023

3. Osher S*, Heaton H*, Wu Fung S*. A Hamilton-Jacobi-based Proximal Operator, *Proceedings of the National Academy of Sciences*, 120 (14), 2023

4. Vidal A, Wu Fung S, Tenorio L, Osher S, Nurbekyan L. Taming Hyperparameter Tuning in Continuous Normalizing Flows Using the JKO Scheme, *Scientific Reports*, 13 (4501), 2023.

5. Chow YT, Wu Fung S, Liu S, Nurbekyan L, Osher S. A Numerical Algorithm for Inverse Problem from Partial Boundary Measurement Arising from Mean Field Game Problem, *Inverse Problems*, 39(1), 014001, 2022

6. Heaton H, Wu Fung S, Osher S. Global Solutions to Nonconvex Problems by Evolution of Hamilton-Jacobi PDEs, *Communications on Applied Mathematics and Computation*, accepted, 2022

7. Ye J†, Wan C†, Wu Fung S. Adaptive Uncertainty-Weighted ADMM for Distributed Optimization, *Journal of Applied and Numerical Optimization*, 4(2), pp. 273-290. 2022

8. Agrawal S, Lee W, Wu Fung S, Nurbekyan L. Random Features for High-Dimensional Nonlocal Mean-Field Games, *Journal of Computational Physics*, 459, pp. 111136. 2022

9. Onken D, Nurbekyan L, Li X, Wu Fung S, Osher S, Ruthotto L. A Neural Network Approach for High-Dimensional Optimal Control, *Transactions on Control Systems Technology*, accepted, 2022

10. Wu Fung S*, Heaton H*, McKenzie D, Li Q, Osher S, Yin W. JFB: Jacobian-free Backpropagation for Implicit Networks, *AAAI Conference on Artificial Intelligence*, 36(6), 6648-6656, 2022

11. Heaton H*, Wu Fung S*, Lin AT*, Osher S, Yin W. Wasserstein-based Projections with Applications to Inverse Problems, *SIAM Journal on Mathematics of Data Science*, 40(2), 581-603, 2022

12. Heaton H*, Wu Fung S*, Gibali A, Yin W. Feasibility-based Fixed Point Networks, *Fixed Point Theory and Algorithms for Sciences and Engineering*, 21, 2021

13. Kan K, Wu Fung S, Ruthotto L. PNKH-B: A Projected Newton-Krylov Method for Large-Scale Bound-Constrained Optimization, *SIAM Journal on Scientific Computing*, 43(5), S704–S726, 2021

14. Lin AT*, Wu Fung S*, Li W, Nurbekyan L, Osher S. Alternating the Population and Agent Control via Two Neural Networks to Solve High-Dimensional Stochastic Mean Field Games, *Proceedings of the National Academy of Sciences*, 118(31). 2021

*denotes co-first author

†undergraduate student at time of publication

15. Onken D, Nurbekyan L, Li X, Wu Fung S, Osher S, Ruthotto L. A Neural Network Approach Applied to Multi-Agent Optimal Control, *European Control Conference 2021 (ECC21)*, pp. 1036-1041. 2021

16. Onken D, Wu Fung S, Li X, Ruthotto L. OT-Flow: Fast and Accurate Continuous Normalizing Flows via Optimal Transport, *AAAI Conference on Artificial Intelligence*, 35(10), 9223-9232, 2021

17. Ruthotto L, Osher S, Li W, Nurbekyan L, Wu Fung S. A Machine Learning Framework for Solving High-Dimensional Mean Field Game and Mean Field Control Problems, *Proceedings of the National Academy of Sciences*, 117(17), 2019-22204, 2020 †

18. Wu Fung S, Tyrväinen S, Ruthotto L, Haber E. ADMM-Softmax: An ADMM Approach for Multinomial Logistic Regression, *Electronic Transactions on Numerical Analysis*, 52, 214-229, 2020

19. Wu Fung S, Di Z. Multigrid Optimization for Large-Scale Ptychographic Phase Retrieval, *SIAM Journal on Imaging Sciences*, 13(1), 214–233. 2020

20. Wu Fung S, Ruthotto L. An Uncertainty-Weighted Asynchronous ADMM Method for Large-Scale PDE Parameter Estimation, *SIAM Journal on Scientific Computing*, 41(5),S129-S148, 2019

21. Wu Fung S, Ruthotto L. A Multiscale Method for Model Order Reduction in PDE Parameter Estimation, *Journal of Computational and Applied Mathematics*, 350, 19-34, 2019

Miscellaneous

- Wu Fung S, McKenzie D, Yin W. Learning to Optimize: Where Deep Learning Meets Optimization and Inverse Problems. *SIAM News 2022*.

Grants and Awards

- NSF DMS 2309810: Optimization-based Implicit Deep Learning, Theory and Applications, funded by the US National Science Foundation. Total budget **$294,995**. Principal Investigator. June 2023 - May 2026.
- NSF DMS 2110745*: Development of Geometrically-Flexible Physics-Based Convolution Kernels, funded by the US National Science Foundation. Total budget **$297,627**. Principal Investigator. June 2021 - May 2024.
- 2022 MGB-SIAM Early Career (MSEC) Fellowship
- 2019 Emory Graduate Student Research Award

†Author contributions: L.R., S.J.O., W.L., L.N., and S.W.F. designed research; L.R., L.N., and S.W.F. performed research; and L.R., S.J.O., W.L., L.N., and S.W.F. wrote the paper.

*Grant received via PI Transfer

Contributed and Invited Research Presentations

- *Explainable AI via Learning to Optimize*
  - invited talk at the Level Set Collective Seminar, UCLA. Dec 4, **2023**
  - invited talk at the Mathematical Biology Research Group Seminar, Colorado School of Mines. October 19, **2023**
- *Using Hamilton Jacobi PDEs in Optimization*
  - invited talk at Data-Driven Methods for Science and Engineering Seminar, University of Washington. April 7, **2023**
  - invited talk at the Mathematical Machine Learning Seminar, Max Planck Institute. March 2, **2023**
  - invited talk at the Center for Mathematics and Artificial Intelligence, George Mason University. February 24, **2023**.
  - invited talk at the Center for Research in Signals and Networks Seminar, Colorado School of Mines. February 11, **2023**.
  - invited talk at the Applied and Computational Mathematics Division Seminar Series. National Institute of Standards and Technology. Boulder, CO, January 24, **2023**
- *Global Solutions to Nonconvex Problems by Evolution of Hamilton-Jacobi PDEs*
  - invited talk at the Spatial Statistics and Kernel Club. Colorado School of Mines. Golden, CO, October 12, **2022**
  - invited talk at the Optimal Transport and Mean Field Game Seminar at University of South Carolina. April 7, **2022**.
  - invited talk at Level Set Collective Seminar, Department of Mathematics, UCLA, Los Angeles, Ca. September, 20, **2022**
  - invited talk at the Early Career Math Colloquium at The University of Arizona. September 21, **2022**.
- *A Deep Learning Approach for Real-Time High-Dimensional Optimal Control*
  - invited talk at the 4th AFOSR Monterey Training Workshop on Computational Issues in Nonlinear Control. May 24, **2023**
  - invited talk at Colorado School of Mines, Math Club/SIAM Student Chapter. March 16, **2022**.
  - invited talk at the Center for Research in Signals and Networks Seminar, Colorado School of Mines. February 18, **2022**.
  - invited talk at the Hamilton-Jacobi PDEs Reunion Conference I, at the Institute for Pure and Applied Mathematics, Los Angeles, California, January 13, **2022**.
- *Efficient Training and Design of Implicit Networks with Applications in Contextual Games*
  - invited talk at the Center for Research in Signals and Networks Seminar, Colorado School of Mines. December 10, **2021**.

- invited talk at SIAM Conference on Optimization. Seattle, Wa. May 31, **2023**

- *Efficient Training of Infinite-depth Neural Networks via Jacobian-free Backpropagation*
  - invited talk at Sacred Heart University. Fairfield, CT. October 3, **2022**.
  - invited talk at SIAM Conference on Mathematics of Data Science. San Diego, CA. September 30, **2022**.
  - invited talk at the CS@Mines Seminar at Colorado School of Mines. Golden, CO. May 3, **2022**.
  - invited talk at SIAM Conference on Uncertainty Quantification. Atlanta, Ga. April 14, **2022**.
  - invited talk at the Math Colloquium Series, at University of Colorado, Colorado Springs, March 31, **2022**.
  - invited talk at the Los Alamos National Lab ML Seminar, February 17, **2022**.
  - invited talk at the The Carl Heiland Lecture Series, at the Department of Geophysics, Colorado School of Mines, February 9, **2022**.
  - invited talk at the Applied Math/Inverse Problems Seminar, at Colorado State University, February 3, **2022**.
  - invited talk at the The Scientific AI Research Group, at the University of Texas at Austin, January 28, **2022**.
  - invited talk at the Center for Wave Phenomena Seminar, Colorado School of Mines. December 6, **2021**
  - invited talk at the AMS Fall Western Sectional Meeting, at University of New Mexico. October 23, **2021**.
  - invited talk at the PDE and Applied Math Seminar at the University of California, Riverside. October 20, **2021**.
  - invited talk at the Statistics, Optimization and Machine Learning Seminar at University of Colorado, Boulder. October 12, **2021**.
  - contributed talk at the Applied Math and Statistics Colloquium at Colorado School of Mines. September 10, **2021**.

- *Wasserstein-based Projections for Inverse Problems*
  - invited talk at the Applied and Computational Mathematics Seminar at Dartmouth College. January 26, **2021**.
  - invited talk at the PDE and Applied Math Seminar at the University of California, Riverside. January 20, **2021**.
  - invited talk at the Deep Learning Seminar at University of South Carolina. December 1, **2020**.
  - invited talk at the Optimal Transport and Mean Field Game Seminar at University of South Carolina. October 14, **2020**.
  - invited talk at the Mathematics and Deep Learning Collective at Iowa State University. October 2, **2020**.

- *A GAN-based Approach for High-Dimensional Stochastic Mean Field Games*, held at
  - invited talk at the Spatial Statistics and Kernel Club. Colorado School of Mines. Golden, CO, March 11, **2022**
  - invited talk at the SIAM Virtual Conference on Mathematics of Data Science. June 25, **2020**
  - invited talk at the Laboratory for Applied Mathematics, Numerical Software, and Statistics (LANS) Seminar at Argonne National Laboratory. June 17, **2020**.
  - invited talk at the Numerical Analysis and Scientific Computing Seminar at Emory University. Atlanta, Ga. March 27, **2020**.
- *A Machine Learning Framework for High-Dimensional Mean Field Games*, held at
  - invited talk at the Optimal Transport and Applications to Machine Learning and Statistics workshop at MSRI, Berkeley, Ca, May 5, **2020**
  - invited talk (joint with Stanley Osher) at the High Dimensional Hamilton-Jacobi Methods in Control and Differential Games workshop at IPAM, Los Angeles, Ca, April 1, **2020**
  - contributed poster in the Intersections between Control, Learning and Optimization workshop at IPAM, Los Angeles, Ca, February 24, **2020**
  - invited talk at the Level Set Collective Seminar, Department of Mathematics, UCLA, Los Angeles, Ca. December 3, **2019**
- *Adaptive Multiscale and Asynchronous Optimization Methods for Large-Scale PDE Parameter Estimation*, held at
  - invited talk at the Level Set Collective Seminar, Department of Mathematics, UCLA, Los Angeles, Ca. July 30, **2019**
  - invited talk at AMS Spring Southeastern Sectional Meeting, Auburn, AL, March 17, **2019**
  - invited talk at SIAM Conference on Computational Science and Engineering, Spokane, Wa. February 27, **2019**.
- *Large-Scale Classification using Multinomial Regression and ADMM*
  - contributed poster at Georgia Scientific Computing Symposium. Atlanta, Ga. February 16, **2019**
- *Multilevel Algorithms for Ptychographic Phase Retrieval*, held at various occasions:
  - contributed talk at the Summer Argonne Student Symposium at Argonne National Laboratory. Lemont, Il. July 26, **2018**
  - invited talk at the Advanced Photon Source at Argonne National Laboratory. Lemont, Il. July 16, **2018**
- *An Uncertainty-Weighted ADMM Method for Large-Scale PDE Parameter Estimation*, held at various occasions:
  - invited talk at SIAM Conference on Uncertainty Quantification. Garden Grove, Ca. April 19, **2018**

- contributed talk at Fifteen Copper Mountain Conference on Iterative Methods. Copper Mountain, Co. March 26, 2018
- invited talk at Spelman College. Atlanta, Ga, February 26, **2018**
- contributed poster at Georgia Scientific Computing Symposium. Atlanta, Ga. February 24, **2018**
- contributed talk at the Scientific Computing Seminar at Emory University. Atlanta, Ga, USA, October 13, **2017**

- *jInv - A Flexible Julia Package for Parallel PDE Parameter Estimation*, held at various occasions:
  - contributed e-poster at SIAM Conference on Computer Science and Engineering, Atlanta, GA, March 1, **2017**
  - contributed poster, Georgia Scientific Computing Symposium. Atlanta, Ga. February 20, 2016
- *PDE-Constrained Optimization with Multiscale Methods*, held at various occasions:
  - invited talk at SIAM Annual Meeting Conference. Pittsburgh, Pa, USA. July 10 - 14, **2017**
  - invited talk at SIAM Conference on Computational Science and Engineering. Atlanta, Ga, USA, March 3, **2017**
  - contributed talk at the Scientific Computing Seminar at Emory University. Atlanta, Ga, USA, February 17, **2017**

Teaching

- Spring2024
  - MATH 598A/EENG 521: Numerical Optimization (Graduate Level), Colorado School of Mines
  - MATH 598B: Mathematical Foundations of Interpretability and Alignment for Large Language Models, Colorado School of Mines
- Fall 2023
  - MATH 307: Intro to Scientific Computing, Section A, Colorado School of Mines
- Spring 2023
  - MATH 598: Numerical Optimization (Graduate Level), Colorado School of Mines
- Fall 2022
  - MATH 307: Intro to Scientific Computing, Section A, Colorado School of Mines
- Spring 2022
  - MATH 307: Intro to Scientific Computing, Section A, Colorado School of Mines

- Fall 2021
  - MATH 307: Intro to Scientific Computing, Section A, Colorado School of Mines
  - CSCI 499: Independent Study
- Spring 2021
  - MATH199: Directed Research in Mathematics, Section 9, UCLA (online)
  - MATH 151A: Applied Numerical Methods I, Sections 1 & 2 , UCLA (online)
- Winter 2021
  - MATH 270C: Computational Linear Algebra (Graduate Level), Section 1, UCLA (online)
- Fall 2020
  - MATH 151B: Applied Numerical Methods II, Section 1, UCLA (online)
- Spring 2020
  - MATH 151A: Applied Numerical Methods I, Sections 1 & 2 , UCLA (online)
- Winter 2020
  - MATH 151B: Applied Numerical Methods II, Section 1, UCLA
- Fall 2019
  - MATH 151A: Applied Numerical Methods I, Section 3, UCLA
- Fall 2016
  - MATH 111: Introductory Calculus, Emory University
- Spring 2016
  - MATH 111: Introductory Calculus, Emory University
- Fall 2015
  - MATH 111: Introductory Calculus, Emory University
- Spring 2015
  - MATH 351: Partial Differential Equations, Emory University (TA)
- Fall 2014
  - MATH 212: Ordinary Differential Equations, Emory University (TA)

Mentoring

- Graduate Student Supervision

- Michael Ivanitsky. Project: Reinforcement Learning Informed by Biological Processes. Co-advised with Cecilia Diniz-Behn, Colorado School of Mines, since January 2022.
- Soraya Terrab. Project: Data-Driven Multiwavelet Methods for Discontinuity Detection. Co-advised with Jennifer Ryan, Colorado School of Mines, since January 2022.
- Alexander Vidal. Project: Optimal Transport-based Continuous Normalizing Flows, since August 2022.

○ Undergraduate Student Supervision

- Amandin Chyba and Jordan Pettyjohn. Project: *Logical Extrapolation via Implicit Deep Learning*. Colorado School of Mines, since August 2022.
- Ibrohim Nosirov. Project: *Deep Learning Methods for Signal Processing*. Colorado School of Mines, September 2021 - December 2021. Co-advised with Mike Wakin
- Sudhanshu Agrawal. Project: *Machine Learning for High-Dimensional Non-Local Mean Field Games*. UCLA, January 2020 - February 2022. Co-advised with Levon Nurbekyan
- Richard Yim. Project: *Learned Inverse Scale Space Flows*. UCLA, January 2020 - June 2020.
- Caleb Wan and Jiangping Ye. Project: *Adaptive Uncertainty-Weighted ADMM Methods for Machine Learning*. UCLA, July 2020 - December 2021.

○ Emory 2022 REU/RET Program on Model Meets Data. Project: Implicit Deep Learning for Inverse Problems.

- Linghai Liu, Brown University
- Allen Tong, UCLA
- Lisa Zhou, UC Berkeley

○ Research in Industrial Projects for Students (RIPS). Institute for Pure and Applied Mathematics, UCLA. June 2020 - Aug 2020. Project: *Large-Scale Inventory Optimization*

- Miranda Kaiser, Rensselaer Polytechnic Institute
- Julia Balukonis, Providence College
- Rachel Fan, Vanderbilt University
- Rong (Hugh) Jiang, UC Berkeley

Other Skills

○ Programming Languages: Python, Julia, Matlab

○ Languages: Spanish (native), English (fluent), French (fluent), Cantonese (fluent)

Seminar and Minisymposium Organization

○ Seminar Organization

- Co-organizer of Mines Optimization and Deep Learning Seminar, Colorado School of Mines
- Co-organizer of Applied Mathematics and Statistics Colloquium, Colorado School of Mines
- Organizer of Kernel Club Seminar, Colorado School of Mines

Minisimposium Organization

- Co-organizer of mini-symposium on *Advances in Optimization and Feasibility Methods for and with Machine Learning* at SIAM Conference on Optimization, Seatle, Washington. May 2023
- Co-organizer of mini-symposium on *Advances in Learning to Optimize and Optimizing to Learn* at SIAM Conference on Mathematics of Data Science, San Diego, California. September 2022
- Co-organizer of mini-symposium on *Deep Learning Methods for Optimization* at SIAM Conference on Uncertainty Quantification, Atlanta, Georgia, USA. April 2022
- Co-organizer of mini-symposium on *Advances in Regularization Techniques for Ill-Posed Problems* at the SIAM Conference on Imaging Sciences, Toronto, Canada. July, 2020
- Co-organizer of mini-symposium on *Advances in Optimal Control for and with Machine Learning* at the SIAM Conference on Mathematics of Data Science, Cincinnati, Ohio. May, 2020
- Co-organizer of mini-symposium on *Mathematical Advances in Deep Learning* at the SIAM Conference on Computational Science and Engineering, Spokane, Washington. February, 2019

Professional Activities and Affiliations

- Reviewer for the following journals and conferences:
  - Physica D: Nonlinear Phenomena
  - SIAM Journal on Numerical Analysis
  - SIAM Journal on Scientific Computing
  - SIAM Journal on Imaging Sciences
  - Frontiers in Applied Mathematics and Statistics
  - Mathematical and Scientific Machine Learning Conference (MSML)
  - Journal of Applied and Numerical Optimization (JANO)
  - Inverse Problems
- Co-founder of the Mines Optimization and Deep Learning research group.
- Board Member for the Emory SIAM Student Chapter. Aug 2014 - May 2019
- Member of the Brown University Immigrant Rights Coalition. Aug 2011 - May 2014