Samy Wu Fung

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Appointments

- Assistant Professor. Department of Applied Mathematics and Statistics. Colorado School of Mines. August 2021 - present
- Assistant Professor. Department of Computer Science. Colorado School of Mines. May 2022 - 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

Funding

- 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.

Honors and Recognition

- 2024 Laney Early Career Alumni Award, April 16, 2024
  - recognizes a recent graduate of a Laney Graduate School program who has distinguished themselves in service to their fields of endeavor, to Emory, and to society in general.
- Plenary Speaker at the 2024 Georgia Scientific Computing Symposium, Feb 24, 2024

- 2022 MGB-SIAM Early Career (MSEC) Fellow
  - Awarded annually to 8 early career mathematicians for their contributions to the field and to diversity.
- 2019 Emory Graduate Student Research Award
  - Awarded annually to one graduating PhD student for their research achievements

Preprints/Submitted Articles

1. Vidal A, Wu Fung S, Osher S, Tenorio L, Nurbekyan L. Kernel Expansions for High-Dimensional Mean Field Control with Nonlocal Interactions, arXiv:2405.10922, 2024.
2. 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.
3. McKenzie D, Wu Fung S, Heaton H, Yin W. Faster Predict-and-Optimize with Three-Operator Splitting, arXiv:2301.13395, 2023.

Published/Accepted Articles

1. McKenzie D, Heaton H, Li Q, Wu Fung S, Osher S, Yin W. Three-Operator Splitting for Learning to Predict Equilibria in Convex Games. *SIAM Journal on Mathematics of Data Science*. Accepted, 2024
2. 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.
3. Heaton H*, Wu Fung S*. Explainable AI via Learning to Optimize, *Scientific Reports*, 13 (10103), 2023
4. Osher S*, Heaton H*, Wu Fung S*. A Hamilton-Jacobi-based Proximal Operator, *Proceedings of the National Academy of Sciences*, 120 (14), 2023
5. 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.
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*, 1–21, 2023
7. 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

*denotes co-first author

8. 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

9. 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

10. 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*, 31(1), 235-251, 2022

11. 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

12. 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

13. 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

14. 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

15. 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

16. 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

17. 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

18. 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 [†]

19. 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

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

[†]undergraduate student at time of publication

[†]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.

21. 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

22. 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*.

Contributed and Invited Research Presentations

- *Explainable AI via Learning to Optimize*
  - plenary speaker at the 2024 Georgia Scientific Computing Symposium, Emory University. Feb 24, **2024**
  - 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 Julıa 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: Mechanistic Interpretability of Maze-Solving Transformers. 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