Sam D. Buchanan

Postdoctoral Scholar
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Professional Experience

2025– **Postdoctoral Scholar**
University of California, Berkeley

2022–25 **Research Assistant Professor**
Toyota Technological Institute at Chicago

Education

2016–22 **PhD, Electrical Engineering**
Columbia University in the City of New York
Advisor: John Wright
Thesis: Deep Networks Through the Lens of Low-Dimensional Structure: Towards Mathematical and Computational Principles for Nonlinear Data

2017 **MS, Electrical Engineering**
Columbia University in the City of New York

2010–14 **BS, Electrical Engineering** (with distinction)
University of Kansas

Awards and Honors

2022 Eli Jury Award, Columbia University Electrical Engineering Department
2017 NDSEG Fellow, US Department of Defense (award rate: $\approx$ 7%)
2016 Tesla Scholar, Columbia University Electrical Engineering Department
2014 Foreign Language and Area Studies Fellowship, US Department of Education

Publications

Preprint

2025 S. Buchanan*, D. Pai*, Y. Ma, and V. D. Bortoli, "On the edge of memorization in diffusion models," *arXiv [cs.LG]*, Aug. 2025. arXiv: 2508.17689 [cs.LG].

*denotes equal contribution

Z. Fang, M. Díaz, S. Buchanan, and J. Sulam, "Beyond scores: Proximal diffusion models," *arXiv [cs.LG]*, Jul. 2025. arXiv: 2507.08956 [cs.LG].

2022 S. Buchanan, J. Yan, E. Haber, and J. Wright, "Resource-efficient invariant networks: Exponential gains by unrolled optimization," Mar. 2022. arXiv: 2203.05006 [cs.CV].

Book

2025 S. Buchanan*, D. Pai*, P. Wang, and Y. Ma, *Learning Deep Representations of Data Distributions*. Online, Aug. 2025, https://ma-lab-berkeley.github.io/deep-representation-learning-book/.

Journal

2024 Y. Yu*, S. Buchanan*, D. Pai*, T. Chu, Z. Wu, S. Tong, H. Bai, Y. Zhai, B. D. Haeffele, and Y. Ma, "White-box transformers via sparse rate reduction: Compression is all there is?" *Journal of Machine Learning Research*, vol. 25, pp. 1–129, Sep. 2024.

Conference

2024 Z. Fang*, S. Buchanan*, and J. Sulam, "What's in a prior? Learned proximal networks for inverse problems," in *International Conference on Learning Representations*, May 2024.

D. Pai, Z. Wu, S. Buchanan, Y. Yu, and Y. Ma, "Masked completion via structured diffusion with white-box transformers," in *International Conference on Learning Representations*, May 2024.

Y. Yu*, T. Chu*, S. Tong, Z. Wu, D. Pai, S. Buchanan, and Y. Ma, "Emergence of segmentation with minimalistic white-box transformers," in *Conference on Parsimony and Learning (CPAL)*, Jan. 2024.

2023 Y. Yu, S. Buchanan, D. Pai, T. Chu, Z. Wu, S. Tong, B. D. Haeffele, and Y. Ma, "White-box transformers via sparse rate reduction," in *Advances in Neural Information Processing Systems (NeurIPS)*, Dec. 2023.

B. Yi, W. Zeng, S. Buchanan, and Y. Ma, "Canonical factors for hybrid neural fields," in *International Conference on Computer Vision (ICCV)*, Oct. 2023.

2021 T. Wang, S. Buchanan, D. Gilboa, and J. Wright, "Deep networks provably classify data on curves," in *Advances in Neural Information Processing Systems*, vol. 34, Curran Associates, Inc., Dec. 2021, pp. 28 940–28 953.

S. Buchanan, D. Gilboa, and J. Wright, "Deep networks and the multiple manifold problem," in *International Conference on Learning Representations*, Jan. 2021.

2019 D. Gilboa, S. Buchanan, and J. Wright, "Efficient dictionary learning with gradient descent," in *Proceedings of the 36th International Conference on Machine Learning*,

*denotes equal contribution

ser. Proceedings of Machine Learning Research, vol. 97, PMLR, 2019, pp. 2252–2259.

2018 S. Buchanan, T. Haque, P. Kinget, and J. Wright, "Efficient model-free learning to overcome hardware nonidealities in analog-to-information converters," in *2018 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Apr. 2018, pp. 3574–3578.

Invited Talks

2024 *"White-Box Transformers via Sparse Rate Reduction"*, Workshop on Privacy and Interpretability in Generative AI: Peering into the Black Box, November.

"White-Box Transformers via Sparse Rate Reduction", Asilomar Special Session "Mathematics in Generative AI", October.

"White-Box Transformers via Sparse Rate Reduction", "Mathematics of Deep Learning" Workshop, Casa Matemática Oaxaca (CMO), June.

"White-Box Architecture Design via Unrolled Optimization and Compression", "Mathematics of Deep Learning" Workshop, Casa Matemática Oaxaca (CMO), June.

"White-Box Transformers via Sparse Rate Reduction", Toyota Technological Institute Research Center for Smart Information Technology Research Seminar, April.

"White-Box Transformers via Sparse Rate Reduction", Redwood Seminar (UC Berkeley Neuroscience), February.

2023 *"Deep Networks and the Multiple Manifold Problem"*, KU Eichstätt-Ingolstadt MIDS Seminar, December.

2022 *"Deep Networks and the Multiple Manifold Problem"*, U Michigan CSP Seminar, December.

"Deep Networks and the Multiple Manifold Problem", SIAM MDS 2022 Minisymposium "The Role of Data Geometry in High-Dimensional Learning", September.

"Deep Networks Through the Lens of Low-Dimensional Structure", Talks at TTIC, April.

"Deep Networks Through the Lens of Low-Dimensional Structure", Johns Hopkins MINDS Seminar, March.

Tutorials and Teaching

2025 **Tutorial**, Learning Deep Low-dimensional Models from High-Dimensional Data: From Theory to Practice

ICCV 2025 Tutorial, October 2025 (forthcoming)

Tutorial, International Artificial Intelligence Summer School 2025

IAISS 2025 Lectures, September 2025 (forthcoming)

Guest Lecture, Introduction to Unsupervised Learning (`EEC 289A`)

UC Davis; Instructor: Prof. Yubei Chen

Lecture: White-Box Transformers via Sparse Rate Reduction

Tutorial, Deep Representation Learning: from Knowledge to Intelligence
CPAL 2025 Tutorial, March 2025

2024 **Tutorial**, Learning Deep Low-Dimensional Models from High-Dimensional Data: From Theory to Practice
CVPR 2024 Tutorial, June 2024
Lecture: White-Box Transformers via Sparse Rate Reduction

Guest Lecture, Optimization Methods for Signal and Image Processing and Machine Learning (`EECS 559`)
University of Michigan; Instructor: Prof. Qing Qu
Lecture: White-Box Transformers via Sparse Rate Reduction and Unrolled Optimization

Tutorial, Building White-Box Deep Neural Networks
ICASSP 2024 Tutorial, April 2024

Tutorial, Learning Deep Low-dimensional Models from High-Dimensional Data: From Theory to Practice
CPAL 2024 Tutorial, January 2024
Lecture: White-Box Transformers via Sparse Rate Reduction

2023 **Tutorial**, Learning Nonlinear and Deep Low-Dimensional Representations from High-Dimensional Data: From Theory to Practice
ICASSP 2023 Short Course, June 2023
Lecture: Deep Representation Learning from the Ground Up

Tutorial, Learning Low-Dimensional Structure via Deep Networks
SLowDNN Workshop 2023 Tutorial, January 2023

2022 **Tutorial**, Low-Dimensional Models for High-Dimensional Data: From Linear to Nonlinear, Convex to Nonconvex, and Shallow to Deep
ICASSP 2022 Short Course, May 2022
Lecture: Learning Low-Dimensional Structures via Deep Networks

2018, 2019 **Teaching Assistant**, Sparse Representation and High-Dimensional Geometry (`ELEN 6886`)
Columbia University
Developed a suite of theoretical and computational exercises for the textbook High-Dimensional Data Analysis with Low-Dimensional Models: Principles, Computation, and Applications.

Professional Service

Conference and Workshop Organization

2025 **Web Chair**, Second Conference on Parsimony and Learning (CPAL)
Stanford University, CA

2024 **Organizer**, SIAM MDS 2024 Minisymposium "Mathematical Principles in Foundation Models"
Atlanta, GA

Organizer, Collaboration on the Theoretical Foundations of Deep Learning Annual Meeting

Halıcıoğlu Data Science Institute (UCSD), San Diego

Web Chair, Inaugural Conference on Parsimony and Learning (CPAL)

Hong Kong University, Hong Kong

2023 **Organizer**, Collaboration on the Theoretical Foundations of Deep Learning Annual Meeting

TTIC, Chicago

Tutorial Chair, 3rd Workshop on Seeking Low-Dimensionality in Deep Neural Networks

MBZUAI, Abu Dhabi

Academic Committee Work

2024 **Member**, Toyota Technological Institute at Chicago (TTIC) Diversity, Equity, and Inclusion Committee

Journal Reviewing

IEEE-JSTSP, IEEE-TPAMI, IEEE-TIT, JMLR, MCSS, TMLR

Conference ACing

NeurIPS 24, 25

Conference Reviewing

CVPR 19*, 21*; ICLR 22*, 23, 24; ICML 21*, 22, 23; NeurIPS 20*, 21, 22*, 23

*denotes a designation of reviewer quality ("outstanding reviewer", etc.)