

Sam D. Buchanan

Research Assistant Professor
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Research Interests

Efficient and transparent machine learning; generative AI; representation learning; AI for science, esp. inverse problems in vision and imaging

Professional Experience

2022– **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

Publications

Preprint

- 2022 S. Buchanan, J. Yan, E. Haber, and J. Wright, “Resource-efficient invariant networks: Exponential gains by unrolled optimization,” Mar. 2022. arXiv: [2203.05006](https://arxiv.org/abs/2203.05006) [cs.CV].

Journal

- 2023 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*, 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

*denotes equal contribution

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), 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

- 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, **Teaching Assistant, Sparse Representation and High-Dimensional Geometry (ELEN 6886)**

2019

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

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.)