

# Zhihui Zhu

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## Education

2017	Ph.D. in Electrical Engineering (Dr. Michael Wakin, advisor)	Colorado School of Mines
2012	B.E. in Telecommunications Engineering (Dr. Gang Li, advisor), winner of Best Bachelor's Thesis Award (1/125)	Zhejiang University of Technology Jianxing Honors College

## Positions

2022-	Assistant Professor	Ohio State University Department of Computer Science & Engineering
2020-2022	Assistant Professor	University of Denver Department of Electrical & Computer Engineering
2018-2019	Postdoctoral Fellow (Dr. René Vidal, advisor)	Johns Hopkins University Center for Imaging Science Mathematical Institute for Data Science
2014-2017	Research Assistant (Dr. Michael Wakin, advisor)	Colorado School of Mines Dept. of Electrical Engineering
2013-2014	Teaching Assistant	Colorado School of Mines Dept. of Electrical Engineering
2010-2013	Research Assistant (Dr. Gang Li, advisor)	Zhejiang University of Technology Zhejiang Key Lab. for Signal Processing

## Honors

2025	Best Paper Award	ICDM UGHS
2024	Ralph E. Powe Junior Faculty Enhancement Awards	ORAU
2021	Research, Scholarship, and Creative Work Faculty Recognition	Univ. Denver
2019	Finalist for the Best Student Paper Award	IEEE CAMSAP
2018	Electrical Engineering Graduate Research Award	Colorado School of Mines
2013	National Scholarship	Ministry of Education of PRC
2012	Best Bachelor's Thesis Award (1/125) for the Thesis "On The Sparse Representation of Signals in Compressive Sensing"	ZJUT
2011	Meritorious Winner in the Mathematical Contest in Modeling (MCM, sponsored by SIAM, NSA, and INFORMS)	

## Research Support

2024-2027	"Collaborative Research: RI: Medium: Principled Approaches to Deep Learning for Low-dimensional Structures," OSU PI, \$400K, NSF Division of Information and Intelligent Systems (Collaborative with Q. Qu at UMich and Y. Ma at UC Berkeley)
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2024-2027	“Collaborative Research: Scalable, Robust, and Distributed Nonconvex Approaches for Structured Tensor Recovery,” OSU PI, \$250K, NSF Division of Electrical, Communications and Cyber Systems (Collaborative with S. Li at ISU)
2024-2025	“Geometrization of Deep Representation Learning for AI Transparency,” PI, \$10K, Oak Ridge Associated Universities (ORAU)
2023-2026	“Collaborative Research: RI: Medium: Principles for Optimization, Generalization, and Transferability via Deep Neural Collapse,” OSU PI, \$400K, NSF Division of Information and Intelligent Systems (Collaborative with J. Sulam at JHU and Q. Qu at UMich)
2023	“Nonconvex Optimization for Efficiently Characterizing Quantum Network,” PI, \$10K, CQISE Partnership Seed Award (Collaborative with B. Kirby at ARL)
2021-2025	“Collaborative Research: CIF: Medium: Structured Inference and Adaptive Measurement Design in Indirect Sensing Systems,” DU then OSU PI, \$344K, NSF Division of Computing and Communication Foundations (Collaborative with M. Wakin and G. Tang at Colorado School of Mines)
2020-2024	“Collaborative Research: CIF: Small: Deep Sparse Models: Analysis and Algorithms,” DU then OSU PI, \$205K, NSF Division of Computing and Communication Foundations (Collaborative with J. Sulam at Johns Hopkins University)

## Preprints<sup>1</sup>

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1. Z. Qin, M. B. Wakin, and Z. Zhu, “Guaranteed Nonconvex Factorization Approach for Tensor Train Recovery,” arxiv preprint, 2024.
2. T. Ding, T. Chen, H. Zhu, J. Jiang, Y. Zhong, J. Zhou, G. Wang, Z. Zhu, I. Zharkov, and L. Liang, “The efficiency spectrum of large language models: An algorithmic survey,” arXiv:2312.00678, 2023.
3. P. Wang, X. Li, C. Yaras, Z. Zhu, L. Balzano, W. Hu, and Q. Qu, “Understanding deep representation learning via layerwise feature compression and discrimination,” arXiv preprint arXiv:2311.02960, 2023.

## Book Chapters

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1. R. Vidal, Z. Zhu, and B. Haefele, “Optimization Landscape of Neural Networks,” in P. Grohs and G. Kutyniok (Eds.), *Mathematics Aspects of Deep Learning*, Cambridge University Press, 2022.

## Journal Publication

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1. Z. Qin, M. B. Wakin, and Z. Zhu, “Guaranteed Nonconvex Factorization Approach for Tensor Train Recovery,” Journal of Machine Learning Research, 2025.
2. Z. Zhu, J. M. Lukens, and B. T. Kirby, “On the connection between least squares, regularization, and classical shadows,” *Quantum*, 2024.
3. X. Li, S. Liu, J. Zhou, X. Lu, C. Fernandez-Granda, Z. Zhu, Q. Qu, “Principled and efficient transfer learning of deep models via neural collapse,” *Transactions on Machine Learning Research*, 2024.

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<sup>1</sup>\*indicates equal contribution.

4. Z. Qin, C. Jameson, Z. Gong, M. B. Wakin, and Z. Zhu, “Quantum State Tomography for Matrix Product Density Operators,” *IEEE Transactions on Information Theory*, 2024.
5. Z. Qin, X. Tan, Z. Zhu, “Convergence Analysis for Learning Orthonormal Deep Linear Neural Networks,” *IEEE Signal Processing Letters*, 2024.
6. Z. Zhu and M. B. Wakin, “Time-Limited Toeplitz Operators on Abelian Groups: Applications in Information Theory and Subspace Approximation,” *Pure and Applied Functional Analysis*, vol. 8, no. 2, pp. 775-808, 2023.
7. C. Wang, Z. Gu, and Z. Zhu, “Seismic Data Reconstruction and Denoising by Enhanced Hankel Low-Rank Matrix Estimation,” *IEEE Transactions on Geoscience and Remote Sensing*, 2023.
8. J. Sulam, C. You, and Z. Zhu, “Recovery and Generalization in Over-Realized Dictionary Learning,” *Journal of Machine Learning Research*, vol. 23, no. 135, pp. 1-23, 2022.
9. Z. Zhu and M. B. Wakin, “Time-Limited Toeplitz Operators on Abelian Groups: Applications in Information Theory and Subspace Approximation,” to appear in *Pure and Applied Functional Analysis*, 2022.
10. Z. Zhu\*, Q. Li\*, G. Tang, and M. B. Wakin, “The Global Optimization Geometry of Low-Rank Matrix Optimization,” *IEEE Transactions on Information Theory*, vol. 67, no. 2, pp. 1308-1331, 2021.
11. X. Li\*, S. Chen\*, Z. Deng, Q. Qu, Z. Zhu, and A.M.-C. So, “Weakly Convex Optimization over Stiefel Manifold Using Riemannian Subgradient-Type Methods,” *SIAM Journal on Optimization*, vol. 31, no. 3, pp. 1605–1634, 2021.
12. X. Li, Z. Zhu, Q. Li, and K. Liu, “A Provable Splitting Approach for Symmetric Nonnegative Matrix Factorization,” *IEEE Transactions on Knowledge and Data Engineering*, 2021.
13. K. Liu, X. Li, Z. Zhu, L. Brand, and H. Wang, “Factor-Bounded Nonnegative Matrix Factorization,” *ACM Transactions on Knowledge Discovery from Data*, vol. 15, pp. 1-18, 2021.
14. Y. Li, Z. Zhu, J. Yu, and Y. Zhang, “Learning Deep Cross-Modal Embedding Networks for Zero-Shot Remote Sensing Image Scene Classification,” to appear in *IEEE Transactions on Geoscience and Remote Sensing*, 2021.
15. Q. Qu, X. Li, and Z. Zhu, “Exact Recovery of Multichannel Sparse Blind Deconvolution via Gradient Descent,” *SIAM Journal on Imaging Sciences*, vol. 13, no. 3, pp. 1630-1652, 2020.
16. Y. Li, Y. Zhang, and Z. Zhu, “Error-Tolerant Deep Learning for Remote Sensing Image Scene Classification,” *IEEE Transactions on Cybernetics*, vol. 51, pp. 1756-1768., 2020.
17. S. Li, Q. Li, Z. Zhu, G. Tang, and M. B. Wakin, “The Global Geometry of Centralized and Distributed Low-rank Matrix Recovery without Regularization,” *IEEE Signal Processing Letters*, vol. 27, pp. 1400-1404, 2020.
18. X. Li\*, Z. Zhu\*, A.M.-C. So, and R. Vidal, “Nonconvex Robust Low-rank Matrix Recovery,” *SIAM Journal on Optimization*, vol. 30, no. 1, pp. 660-686, 2020.
19. Z. Zhu, D. Soudry, Y. C. Eldar, and M. B. Wakin, “The Global Optimization Geometry of Shallow Linear Neural Networks,” *Mathematical Foundations of Deep Learning in Imaging Science*, special issue of *Journal of Mathematical Imaging and Vision*, vol. 62, pp. 279-292, 2020.
20. C. Wang, Z. Zhu, and H. Gu, “Low-rank Seismic Denoising with Optimal Rank Selection for Hankel Matrices,” *Geophysical Prospecting*, 2020, vol. 68, no. 3, pp. 892-909, 2020.

21. Q. Jiang, S. Li, Z. Zhu, H. Bai, X. He, and R. C. de Lamare, "Design of compressed sensing system with probability-based prior information." *IEEE Transactions on Multimedia*, vo. 22, no. 3, pp. 594-609, 2019.
22. Q. Li, Z. Zhu, and G. Tang, "The Non-convex Geometry of Low-rank Matrix Optimization," *Information and Inference: A Journal of the IMA*, vol 8, no. 1, pp. 51-96, March 2019.
23. S. Karnik, Z. Zhu, M. B. Wakin, J. Romberg, and M. A. Davenport, "The Fast Slepian Transform," *Applied and Computational Harmonic Analysis*, vol 46, no. 3, pp. 624-652, May 2019.
24. T. Hong, X. Li, Z. Zhu, and Q. Li, "Optimized Structured Sparse Sensing Matrices for Compressive Sensing," *Signal Processing*, vol. 159, pp. 119-129, June 2019.
25. C. Wang, Z. Zhu, H. Gu, X. Wu, and S. Liu, "Hankel Low-Rank Approximation for Seismic Noise Attenuation," *IEEE Transactions on Geoscience and Remote Sensing*, vol 57, no. 1, pp. 561-573, January 2019.
26. Z. Zhu, S. Karnik, M. Wakin, M. Davenport, and J. Romberg, "ROAST: Rapid Orthogonal Approximate Slepian Transform," *IEEE Transactions on Signal Processing*, vol 66, no. 22, pp. 5887-5901, November 2018.
27. Z. Zhu, G. Li, J. Ding, Q. Li, and X. He, "On Collaborative Compressive Sensing Systems: The Framework, Design and Algorithm," *SIAM Journal on Imaging Sciences*, vol 11, no. 2, pp. 1717-1758, 2018.
28. Z. Zhu, Q. Li, G. Tang, and M. B. Wakin, "Global Optimality in Low-rank Matrix Optimization," *IEEE Transactions on Signal Processing*, vol 66, no. 13, pp. 3614-3628, July 2018.
29. T. Hong and Z. Zhu, "An Efficient Method for Robust Projection Matrix Design," *Signal Processing*, vol. 143, pp. 200-210, February 2018.
30. Z. Zhu, S. Karnik, M. A. Davenport, J. K. Romberg, and M. B. Wakin, "The Eigenvalue Distribution of Discrete Periodic Time-Frequency Limiting Operators," *IEEE Signal Processing Letters*, vol. 25, no. 1, pp. 95–99, January 2018.
31. Z. Zhu and M. B. Wakin, "Approximating Sampled Sinusoids and Multiband Signals Using Multiband Modulated DPSS Dictionaries," *Journal of Fourier Analysis and Applications*, vol. 23, no. 6, pp. 1263–1310, December 2017.
32. Z. Zhu and M. B. Wakin, "On the Asymptotic Equivalence of Circulant and Toeplitz Matrices," *IEEE Transactions on Information Theory*, vol. 63, no. 5, pp. 2975-2992, May 2017.
33. S. Liu, M. Liu, P. Li, J. Zhao, Z. Zhu, and X. Wang, "SAR Image Denoising via Sparse Representation in Shearlet Domain Based on Continuous Cycle Spinning," *IEEE Transactions on Geoscience and Remote Sensing*, vol. 55, no. 5, pp. 2985-2992, 2017.
34. H. Tao, H. Bai, S. Li, and Z. Zhu, "An Efficient Algorithm for Designing Projection Matrix in Compressive Sensing Based On Alternating Optimization," *Signal Processing*, vol. 125, pp. 9-20, 2016.
35. G. Li, Z. Zhu, D. Yang, L. Chang, and H. Bai, "On Projection Matrix Optimization for Compressive Sensing Systems," *IEEE Transactions on Signal Processing*, vol. 61, no. 11, pp. 2887-2898, June 2013.

## Conference Publications—Machine Learning

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1. A. Liu, C. Hill, J. Jiang, Z. Zhu, "Can Reasoning LLMs Eliminate Conformity in Multi-Agent Systems?", IEEE International Conference on Data Mining (ICDM), 2025.

2. Xinyi Ling, Hanwen Du, Zhihui Zhu, Xia Ning, “EcomMMMU: Strategic Utilization of Visuals for Robust Multimodal E-commerce Models”, IJCNLP-AACL, 2025.
3. Xinyi Ling, Hanwen Du, Bo Peng, Zhihui Zhu, Xia Ning, “Captions Speak Louder than Images: Generalizing Foundation Models for E-commerce from High-quality Multimodal Instruction Data”, IJCNLP-AACL, 2025.
4. J. Jiang, J. Zhou, Z. Zhu, “Tracing Representation Progression: Analyzing and Enhancing Layer-Wise Similarity,” International Conference on Learning Representations (ICLR), 2025.
5. X. Chen, Z. Zhu, A. Perrault, “Understanding Learned Representations and Action Collapse in Visual Reinforcement Learning,” Reinforcement Learning Conference, 2025.
6. J. Zhou, J. Jiang, Z. Zhu, “Are all layers created equal: A neural collapse perspective,” Conference on Parsimony and Learning (CPAL), 2025.
7. Lijun Ding, Zhen Qin, Liwei Jiang, Jinxin Zhou, Zhihui Zhu, “A Validation Approach to Over-parameterized Matrix and Image Recovery,” Conference on Parsimony and Learning (CPAL), 2025.
8. X. Chen, Z. Zhu, A. Perrault, “The Distributional Reward Critic Framework for Reinforcement Learning Under Perturbed Rewards,” AAAI, 2025.
9. J. Jiang, J. Zhou, P. Wang, Q. Qu, D. Mixon, C. You, and Z. Zhu, “Generalized neural collapse for a large number of classes,” *International Conference in Machine Learning (ICML)*, 2024.
10. Peng Wang, Huikang Liu, Druv Pai, Yaodong Yu, Zhihui Zhu, Qing Qu, and Yi Ma, “A Global Geometric Analysis of Maximal Coding Rate Reduction,” *International Conference in Machine Learning (ICML)*, 2024.
11. J. Zhou\*, T. Ding\*, T. Chen, J. Jiang, I. Zharkov, Z. Zhu, and L. Liang, “DREAM: Diffusion Rectification and Estimation-Adaptive Models,” CVPR, 2024.
12. Chao Huang, Yibei Guo, Zhihui Zhu, Mei Si, Daniel Blankenberg, Rui Liu, “Quantum Exploration-based Reinforcement Learning for Efficient Robot Path Planning in Sparse-Reward Environment”, IEEE International Conference on Robot and Human Interactive Communication (RO-MAN), 2024.
13. T. Chen, L. Liang, T. Ding, Z. Zhu, and I. Zharkov, “OTOV2: Automatic, Generic, User-Friendly”, *International Conference on Learning Representations (ICLR)*, May 2023.
14. J. Zhou, C. You, X. Li, K. Liu, S. Liu, Q. Qu, and Z. Zhu, “Are All Losses Created Equal: A Neural Collapse Perspective,” *Neural Information Processing Systems (NeurIPS)*, December 2022.
15. Z. Qin, A. Lidiak, Z. Gong, G. Tang, M. B. Wakin, and Z. Zhu, “Error Analysis of Tensor-Train Cross Approximation,” *Neural Information Processing Systems (NeurIPS)*, December 2022.
16. C. Yaras, P. Wang, Z. Zhu, L. Balzano, and Qing Qu, “Neural Collapse with Normalized Features: A Geometric Analysis over the Riemannian Manifold,” *Neural Information Processing Systems (NeurIPS)*, December 2022.
17. X. Dai, M. Li, P. Zhai, S. Tong, X. Gao, S. Huang, Z. Zhu, C. You, and Yi Ma, “Revisiting Sparse Convolutional Model for Visual Recognition,” *Neural Information Processing Systems (NeurIPS)*, December 2022.
18. Jinxin Zhou\*, Xiao Li\*, Tianyu Ding, Chong You, Qing Qu, and Zhihui Zhu, “On the Optimization Landscape of Neural Collapse under MSE Loss: Global Optimality with Unconstrained Features,” *International Conference in Machine Learning (ICML)*, 2022.

19. S. Liu, Z. Zhu, Q. Qu, and C. You, “Robust Training under Label Noise by Over-parameterization,” *International Conference in Machine Learning (ICML)*, 2022.
20. Z. Zhu\*, T. Ding\*, J. Zhou, X. Li, C. You, J. Sulam, and Q. Qu, “A Geometric Analysis of Neural Collapse with Unconstrained Features,” *Neural Information Processing Systems (NeurIPS)*, 2021. (spotlights, top 3%)
21. S. Liu\*, X. Li\*, Y. Zhai, C. You, Z. Zhu, C. Fernandez-Granda, and Q. Qu, “Convolutional Normalization: Improving Deep Convolutional Network Robustness and Training,” *Neural Information Processing Systems (NeurIPS)*, 2021.
22. L. Ding, L. Jiang, Y. Chen, Q. Qu, and Z. Zhu, “Rank Overspecified Robust Matrix Recovery: Subgradient Method and Exact Recovery”, *Neural Information Processing Systems (NeurIPS)*, 2021.
23. T. Chen, B. Ji, T. Ding, B. Fang, G. Wang, Z. Zhu, L. Liang, Y. Shi, S. Yi, and X. Tu, “Only Train Once: A One-Shot Neural Network Training And Pruning Framework”, *Neural Information Processing Systems (NeurIPS)*, 2021.
24. T. Ding, Z. Zhu, R. Vidal, and D. P. Robinson, “Dual Principal Component Pursuit for Robust Subspace Learning: Theory and Algorithms for a Holistic Approach,” *International Conference on Machine Learning (ICML)*, 2021.
25. T. Ding, L. Liang, Z. Zhu, and I. Zharkov, “CDFI: Compression-driven Network Design for Frame Interpolation,” *Computer Vision and Pattern Recognition (CVPR)*, 2021.
26. T. Ding, Z. Zhu, M. C. Tsakiris, R. Vidal, and D. P. Robinson, “Dual Principal Component Pursuit for Learning a Union of Hyperplanes: Theory and Algorithms,” *Artificial Intelligence and Statistics (AISTATS)*, 2021.
27. C. You\*, Z. Zhu\*, Q. Qu, and Y. Ma, “Robust Recovery via Implicit Bias of Discrepant Learning Rates for Double Over-parameterization,” *Neural Information Processing Systems (NeurIPS)*, 2020. (spotlights, top 4%)
28. T. Chen, T. Ding, B. Ji, G. Wang, Y. Shi, S. Yi, X. Tu, and Z. Zhu, “Orthant Based Proximal Stochastic Gradient Method for L-1 Regularized Optimization”, *European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD)*, Ghent, Belgium, September 2020.
29. T. Ding, Y. Yang, Z. Zhu, D. Robinson, R. Vidal, L. Kneip, M. C. Tsakiris, “Robust Homography Estimation via Dual Principal Component Pursuit,” *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, Seattle, Washington, June 2020.
30. Q. Qu, Y. Zhai, X. Li, Y. Zhang, and Z. Zhu, ”Analysis of the Optimization Landscapes for Overcomplete Representation Learning,” *International Conference on Learning Representations (ICLR)*, Addis Ababa, Ethiopia, April 2020. (oral, top 1.85%)
31. Z. Zhu, T. Ding, M.C. Tsakiris, D. Robinson, and R. Vidal, “A Linearly Convergent Method for Non-smooth Non-convex Optimization on Grassmannian with Applications to Robust Subspace and Dictionary Learning,” *Neural Information Processing Systems (NeurIPS)*, Vancouver, Canada, December 2019.
32. Z. Zhu, Q. Li, X. Yang, G. Tang, and M. B. Wakin, “ Global Optimality in Distributed Low-rank Matrix Factorization,” *Neural Information Processing Systems (NeurIPS)*, Vancouver, Canada, December 2019.
33. Q. Qu, X. Li, and Z. Zhu, “ A Nonconvex Approach for Exact and Efficient Multichannel Sparse Blind Deconvolution,” *Neural Information Processing Systems (NeurIPS)*, Vancouver, Canada, December 2019. (spotlights, top 4.2%)

34. Q. Li\*, Z. Zhu\*, and G. Tang, “Alternating Minimizations Converge to Second-Order Optimality Solutions”, *International Conference on Machine Learning (ICML)*, Long Beach, CA, USA, June 2019.
35. T. Ding\*, Z. Zhu\*, T. Ding, M. C. Tsakiris, D. P. Robinson, and R. Vidal, “Noisy Dual Principal Component Pursuit”, *International Conference on Machine Learning (ICML)*, Long Beach, CA, USA, June 2019.
36. Z. Zhu, Y. Wang, D. P. Robinson, D. Naiman, R. Vidal, and M. C. Tsakiris, “Dual Principal Component Pursuit: Improved Analysis and Efficient Algorithms,” *Neural Information Processing Systems (NeurIPS)*, December 2018.
37. Z. Zhu\*, X. Li\*, K. Liu, and Q. Li, “Dropping Symmetry for Fast Symmetric Nonnegative Matrix Factorization,” *Neural Information Processing Systems (NeurIPS)*, December 2018.

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## Workshop Publications—Machine Learning

1. J. Jiang, J. Zhou, Z. Zhu, “On Layer-wise Representation Similarity: Application for Multi-Exit Models with a Single Classifier,” *NeurIPS Workshop on Symmetry and Geometry in Neural Representations*, 2024.
2. X. Li, Z. Zhang, X. Li, S. Chen, Z. Zhu, P. Wang, Q. Qu, “Understanding Diffusion-based Representation Learning via Low-Dimensional Modeling,” *NeurIPS Workshop on Mathematics of Modern Machine Learning*, 2024.
3. C. Yaras, P. Wang, W. Hu, Z. Zhu, L. Balzano, Q. Qu, “Invariant Low-Dimensional Subspaces in Gradient Descent for Learning Deep Matrix Factorizations,” *NeurIPS 2023 Workshop on Mathematics of Modern Machine Learning*, 2023.
4. Z. Zhu\*, T. Ding\*, J. Zhou, X. Li, C. You, J. Sulam, and Q. Qu, “A Geometric Analysis of Neural Collapse with Unconstrained Features,” *Conference on the Mathematical Theory of Deep Learning*, 2021.
5. X. Li, Z. Zhu, A. Man-Cho So, J. D Lee, “Incremental Methods for Weakly Convex Optimization,” *Neural Information Processing Systems (NeurIPS) Workshop on Optimization for Machine Learning (OPT)*, 2020.

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## Conference Publications—Signal Processing

1. H. Yu, Z. Qin, and Z. Zhu, “Learning Approach for Fast Approximate Matrix Factorizations,” *International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*, 2022.
2. Q. Qu, Y. Zhai, X. Li, Y. Zhang, and Z. Zhu, “Analysis of the Optimization Landscapes for Overcomplete Representation Learning,” *IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*, 2020.
3. Q. Li, X. Yang, Z. Zhu, G. Tang, and M. B. Wakin, “The Geometric Effects of Distributing Constrained Nonconvex Optimization Problems,” *IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*, 2019. (candidates for the Best Student Paper Award)
4. Q. Qu, X. Li, and Z. Zhu, “Exact and Efficient Multi-Channel Sparse Blind Deconvolution—a Nonconvex Approach,” *Asilomar Conference on Signals, Systems, and Computers (Asilomar)*, Pacific Grove, CA, USA, November 2019.

5. Q. Li, Z. Zhu, M. B. Wakin, and G. Tang, "The Local Geometry of Orthogonal Dictionary Learning using L1 Minimization," *Asilomar Conference on Signals, Systems, and Computers (Asilomar)*, Pacific Grove, CA, USA, November 2019.
6. Y. Li, Y. Zhang, and Zhihui Zhu, "Learning Deep Networks under Noisy Labels for Remote Sensing Image Scene Classification," *IEEE International Geoscience and Remote Sensing Symposium (IGARSS)*, Yokohama, Japan, July 2019.
7. Q. Li, Z. Zhu, G. Tang, and M. B. Wakin, "The Geometry Of Equality-Constrained Global Consensus Problems," *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, Brighton, UK, May 2019.
8. Z. Zhu, M. Lopez-Santillana, and M. B. Wakin, "Super-Resolution of Complex Exponentials from Modulations with Known Waveforms," *IEEE International Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*, Curacao, Dutch Antilles, December 2017.
9. Z. Zhu, Q. Li, G. Tang, and M. B. Wakin, "Global Optimality in Low-rank Matrix Optimization," *IEEE Global Conference on Signal and Information Processing (GlobalSIP)*, Montreal, Quebec, Canada, November 2017.
10. Z. Zhu, D. Yang, M. B. Wakin, and G. Tang, "A Super-Resolution Algorithm for Multiband Signal Identification," *51st Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, California, October 2017.
11. Z. Zhu, S. Karnik, M. B. Wakin, M. A. Davenport, and J. K. Romberg, "Fast Orthogonal Approximations of Sampled Sinusoids and Bandlimited Signals," *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, New Orleans, March 2017.
12. G. Li, Z. Zhu, H. Bai, and A. Yu, "A New Framework for Designing Incoherent Sparsifying Dictionaries," *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, New Orleans, March 2017.
13. Q. Li, S. Li, H. Mansour, M. Wakin, D. Yang, and Z. Zhu, "JAZZ: A Companion to MUSIC for Frequency Estimation with Missing Data," *IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, New Orleans, March 2017.
14. S. Karnik, Z. Zhu, M. B. Wakin, J. K. Romberg, and M. A. Davenport, "Fast Computations for Approximation and Compression in Slepian Spaces," *IEEE Global Conference on Signal and Information Processing (GlobalSIP)*, Greater Washington, D.C., December 2016.
15. Z. Zhu and M. B. Wakin, "On the Dimensionality of Wall and Target Return Subspaces in Through-the-Wall Radar Imaging," *4th International Workshop on Compressed Sensing Theory and its Applications to Radar, Sonar and Remote Sensing (CoSeRa)*, Aachen, Germany, September 2016.
16. Z. Zhu, G. Tang, P. Setlur, S. Gogineni, M. Wakin, and M. Rangaswamy, "Super-Resolution in SAR Imaging: Analysis With the Atomic Norm," *IEEE Sensor Array and Multichannel Signal Processing (SAM) Workshop*, Rio de Janeiro, Brazil, July 2016.
17. Z. Zhu and M. B. Wakin, "New Analysis of Multiband Modulated DPSS Dictionaries," *Workshop on Signal Processing with Adaptive Sparse Structured Representations (SPARS)*, Cambridge, England, July 2015.
18. Z. Zhu and M. B. Wakin, "Wall Clutter Mitigation and Target Detection Using Discrete Prolate Spheroidal Sequences," *3rd International Workshop on Compressed Sensing Theory and its Applications to Radar, Sonar and Remote Sensing (CoSeRa)*, Pisa, Italy, June 2015.

19. Z. Zhu and M. B. Wakin, "Detection of Stationary Targets Using Discrete Prolate Spheroidal Sequences," *International Review of Progress in Applied Computational Electromagnetics (ACES)*, Williamsburg, Virginia, March 2015.
20. H. Bai, Z. Zhu, G. Li, and S. Li, "Design of Optimal Measurement Matrix for Compressive Detection," *International Symposium on Wireless Communication Systems (ISWCS)*, Ilmenau, Germany, August 2013.
21. S. Li, Z. Zhu, G. Li, L. Chang, and Q. Li, "Projection Matrix Optimization for Block-sparse Compressive Sensing," *IEEE International Conference on Signal Processing, Communication and Computing (ICSPCC)*, KunMing, August 2013.
22. Q. Li, Z. Zhu, S. Tang, L. Chang, and G. Li, "Projection Matrix Optimization Based on SVD for Compressive Sensing Systems," *Chinese Control Conference (CCC)*, July 2013.
23. Z. Zhu, D. Yang, G. Li, and C. Huang, "Stable 2nd Order Adaptive IIR filter Structure for Blind Deconvolution," *International Congress on Image and Signal Processing (CISP)*, Shanghai, October 2011.

## **Tutorials and Short Courses**

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1. "Understanding Deep Representation Learning via Neural Collapse", *IEEE International Conference on Acoustics, Speech and Signal Processing*, April 2024.
2. "Understanding Deep Representation Learning via Neural Collapse", *Conference on Parsimony and Learning (CPAL)*, Jan 2024.
3. "Learning Nonlinear and Deep Low-Dimensional Representations from High-Dimensional Data: From Theory to Practice", *IEEE International Conference on Acoustics, Speech and Signal Processing*, May 2023.
4. "Learned Representations and Low-Dimensional Structures", *The Third Workshop on Seeking Low-Dimensionality in Deep Neural Networks*, Jan 2023.
5. "Low-Dimensional Models for High-Dimensional Data: From Linear to Nonlinear, Convex to Nonconvex, and Shallow to Deep", *2022 IEEE International Conference on Acoustics, Speech and Signal Processing*, May 2022. (10-hours short course with Sam Buchanan, Yi Ma, Qing Qu, John Wright, and Yuqian Zhang)
6. "Nonconvex Approaches for Data Science," *School of Information Science and Technology, ShanghaiTech University*, June 2019.

## **Guest Lectures**

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1. "Geometric Analysis of Neural Collapse with unconstrained features," invited by Dr. Qu for *EECS 559: Optimization Methods for Signal and Image Processing and Machine Learning, University of Michigan-Ann Arbor*, April 2021.
2. "Robust Recovery with Over-parameterized Model," invited by Dr. Qu for *EECS 559: Optimization Methods for Signal and Image Processing and Machine Learning, University of Michigan-Ann Arbor*, April 2021.

## **Invited Presentations**

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1. "Look Inside LLMs: Representation, Memory, Computation", *Ohio State University Symposium on Large Language Models*, Oct 2023.

2. “Efficiently Characterizing Quantum Systems”, *Center for Quantum Information Science and Engineering, Ohio State University*, September 2023.
3. “Neural Collapsed Representation in Deep Learning Classifiers”, *Department of Computer Science, Missouri S&T*, Oct 2022.
4. “Rank-Overspecified Robust Matrix Recovery: Subgradient Method And Exact Recovery”, *International Conference on Continuous Optimization (ICCOPT)*, July 2022.
5. “Geometric Analysis of Neural Collapse”, *Beijing University of Posts and Telecommunications*, June 2022.
6. “Low-dimensional Modeling for Deep Learning”, *IEEE Denver Computer, Information Theory, and Robotics Society*, June 2022.
7. “A Geometric Analysis Of Neural Collapse With Unconstrained Features,” *VITA at University of Texas at Austin*, March 2022.
8. “Low-dimensional Modeling for Deep Learning”, *Applied and Computational Mathematics Seminar, Georgia Institute of Technology*, March 2022.
9. “Low-dimensional Modeling for Deep Learning”, *Department of Computer Science & Engineering, The Ohio State University*, March 2022.
10. “Low-dimensional Modeling for Deep Learning”, *Department of Electrical & Systems Engineering, Washington University in St. Louis*, February 2022.
11. “Landscape Analysis of Neural Collapse with Unconstrained Features,” *The 2nd Workshop on Seeking Low-dimensionality in Deep Neural Networks (SLowDNN)*, November 2021.
12. “A Geometric Analysis Of Neural Collapse With Unconstrained Features,” *Institute for Operations Research and the Management Sciences (INFORMS) Annual Meeting, Special Session on The Interplay between Optimization and Statistics, Anaheim, California*, October 2021.
13. “Landscape Analysis of Neural Collapse with Unconstrained Features”, *Center for Biological & Computational Learning (CBCL), Massachusetts Institute of Technology*, October, 2021.
14. “Landscape Analysis of Neural Collapse”, *Berkeley Learning Theory Group, University of California, Berkeley*, June, 2021.
15. “Robust Recovery with Over-parameterized Model”, Microsoft Research Day, Microsoft, March, 2021.
16. “Robust Recovery with Over-parameterized Model”, Computational Interpretation Group, University of Science and Technology of China, March, 2021.
17. “Provable Nonsmooth Nonconvex Approaches for Low-Dimensional Models”, *Statistics, Optimization and Machine Learning (StaOptML) Seminar*, University of Colorado Boulder, Jan 2020.
18. “Provable Nonsmooth Nonconvex Approaches for Low-Dimensional Models”, Colorado School of Mines, Jan 2020.
19. “Provable Nonsmooth Nonconvex Approaches for Low-Dimensional Models”, *Signal and Information Processing Seminar (SIP) Seminar*, Rutgers University, Dec 2019.
20. “Provable Nonconvex Approaches for Low-rank Models”, *Workshop on Low-Rank Models and Applications (LRMA)*, University of Mons, Belgium, Sep 2019.

21. “A Linearly Convergent Method for Non-Smooth Non-Convex Optimization on the Sphere with Applications to Robust Subspace and Dictionary Learning”, *the Sixth International Conference on Continuous Optimization (ICCOPT)*, Technical University (TU) of Berlin, Aug 2019.
22. “Nonconvex Approaches for Data Science,” *Wuhan University*, June 2019.
23. “Nonconvex Approaches for Data Science,” *Zhejiang University of Technology*, June 2019.
24. “Nonconvex Nonsmooth Approaches for Data Science,” *Center for Data Science*, New York University, April 2019.
25. “Nonconvex Approaches for Data Science,” *University of Denver*, Feb 2019.
26. “Nonconvex Approaches for Data Science,” *George Washington University*, Feb 2019.
27. “Nonconvex Approaches for Data Science,” *University of Utah*, March 2019.
28. “Nonconvex Approaches for Data Science,” *University of Vermont*, March 2019.
29. “Nonconvex Approaches for Data Science,” *University of Hawaii at Manoa*, March 2019.
30. “Nonconvex Geometry of Low-rank Matrix Optimizations,” *JHU Vision Lab*, 2017.
31. “A Super-resolution Algorithm for Multiband Signal Identification,” *51st Asilomar Conference on Signals, Systems and Computers*, Pacific Grove, October 2017.

## **Contributed Presentations**

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1. “Sample-optimal quantum state tomography for structured quantum states in one dimension”,
2. 28th Annual Quantum Information Processing Conference, 2025.
3. “A tale of two regularizers: classical shadows and regularized least squares for quantum estimation”,
4. 28th Annual Quantum Information Processing Conference, 2025.
5. “Regularizing least squares quantum state tomography with classical shadows,” *Conference on Lasers and Electro-Optics (CLEO)*, 2025.
6. “Similarity of Layer-Wise Representations Within Transformers,” *SIAM Conference on Mathematics of Data Science (MDS24)*, 2024.
7. “Object Identification with Less Supervision,” *Northrop Grumman University Research Symposium*, October, 2019.
8. “A Linearly Convergent Method for Non-smooth Non-convex Optimization on Grassmannian with Applications to Robust Subspace and Dictionary Learning,” *Computational Imaging Workshop, Institute for Mathematics and its Applications, University of Minnesota Twin Cities*, October 2019.
9. “Fast Orthogonal Approximations of Sampled Sinusoids and Bandlimited Signals,” *Graduate Research And Discovery Symposium (GRADS)*, Colorado School of Mines, April 2017.
10. “Fast Orthogonal Approximations of Sampled Sinusoids and Bandlimited Signals,” *Computing-Mines Affiliates Partnership Program (C-MAPP) Award Event*, January 2017.
11. “Wall Clutter Mitigation and Target Detection in Through-the-Wall Radar Imaging,” *Graduate Research And Discovery Symposium (GRADS)*, Colorado School of Mines, March 2016.

12. "On the Asymptotic Equivalence of Circulant and Toeplitz Matrices", *2016 February Fourier Talks – FFT 2016, Norbert Wiener Center for Harmonic Analysis and Applications, Department of Mathematics, University of Maryland*, College Park, Maryland, February 2016.
13. "SAR Radar Imaging of Targets Through the Wall," *Graduate Research And Discovery Symposium (GRADS), Colorado School of Mines*, January 2016.
14. "New Analysis of Multiband Modulated DPSS Dictionaries," *Zhejiang Key Laboratory for Signal Processing*, May 2015.
15. "SAR Radar Imaging of Targets Through the Wall", *Graduate Research And Discovery Symposium (GRADS), Colorado School of Mines*, April 2015.

## **Teaching Experience**

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Professor (OSU):	CSE5539 CSE5523	Deep Learning: Models, Theory & Application Machine Learning	(S'23) (F'22, S'24)
Professor (DU):	ENGR4622 ENGR4620 ENCE4631 ENGR3650	Advanced Optimization Large-scale Optimization Machine Learning Probability and Statistics for Engineers	(F'21) (F'20) (S'20,S'21,S'22) (W'20,W'21)
Participant (JHU):	Johns Hopkins Teaching Institute		(May 18)
Lab Instructor (Mines):	EENG 284	Advanced Optimization	(S'14, F'13)
Teaching Assistant (ZJUT):	Signals and Systems		(F'12,S'13)

## **Student Supervision and Advising**

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### **Postdoc**

- Yuxin Dong, co-advising with Xia Ning, 2025-present

### **PhD Students**

- Yichen Gao, 2025-present  
Topic: Machine Unlearning
- Xudong Zhu, Sep. 2024-present  
Topic: Mechanistic Interpretability
- Jiachen Jiang, Sep. 2023-present  
Topic: Deep Representation Learning
- Xi Chen, co-advising with Andrew Perrault, 2023-present  
Topic: Reinforcement Learning
- Jinxin Zhou, Sep. 2021-present  
Topic: Seeking Low Dimensionality in Deep Neural Network
- Qin Zhen, Sep. 2021-present  
Topic: Structured Inference and Adaptive Measurement Design in Indirect Sensing Systems

### **Thesis-based MS Students**

- Elijah Mansur, 2025-present Topic: LLM Reasoning
- Shreya Byreddy, 2022-2023, then at Nationwide  
Topic: Deep Representation Learning via Neural Collapse
- Haiyan Yu, 2021-2022, then PhD student at University of Nottingham Ningbo China.  
Topic: Learning Approach for Fast Approximate Matrix Factorizations

### **Undergraduate Students**

- Ethan Savar, Computer Science & Engineering, Ohio State University, 2024

### **K-12 Students**

- Alina Liu, summer 2024  
Topic: Prompt engineering for LLM
- Jackson Sean, summer 2023, then Computer Science at Carnegie Mellon University  
Topic: Understanding word embeddings in LLM

### **Other students (individual studies, research projects):**

- Jiawei Lu, Ohio State University, 2023-2024.
- Kerrie Cheng, 2024.

### **Member of Thesis Proposal Committee**

Vahid Ahmadi Kalkhorani, Computer Science & Engineering, Ohio State University, 2025  
Vishal Dey, Computer Science & Engineering, Ohio State University, 2024  
Gu Yu, Computer Science & Engineering, Ohio State University, 2024  
Linbo Mo, Computer Science & Engineering, Ohio State University, 2024  
Zachary Condon, Mechanical and Aerospace Engineering, Ohio State University, 2023  
Bo Peng, Computer Science & Engineering, Ohio State University, 2023  
Ziwei Guan, Electrical & Computer Engineering, Ohio State University, 2022

### **Member of Thesis Defense Committee**

Gu Yu, Computer Science & Engineering, Ohio State University, 2025  
Linbo Mo, Computer Science & Engineering, Ohio State University, 2024  
Zachary Condon, Mechanical and Aerospace Engineering, Ohio State University, 2024  
Shreya Byreddy, Computer Science & Engineering, Ohio State University, 2023  
Ziwei Guan, Electrical & Computer Engineering, Ohio State University, 2023  
Dongcheng He, Electrical & Computer Engineering, University of Denver, 2022  
Rohola Zandie, Electrical & Computer Engineering, University of Denver, 2022  
Fahad Alhomayani, Electrical & Computer Engineering, University of Denver, 2021  
Tianyu Ding, Applied Mathematics & Statistics, Johns Hopkins University, 2021

### **Professional Activities**

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#### **Professional Societies**

IEEE, SIAM, ACM

#### **Editorial Activity**

*Action Editor for Transactions on Machine Learning Research (TMLR, 2022-present)*  
First TMLR Outstanding Paper Committee, 2023  
*Guest editor for IEEE Journal of Selected Topics in Signal Processing Special Issue on Seeking Low-dimensionality in Deep Neural Networks (SLowDNN)*

#### **Technical Program Committees (Area Chair)**

*Machine Learning for Signal Processing (MLSP TC) of IEEE Signal Processing Society*  
*International Conference on Machine Learning (ICML)*  
*Neural Information Processing Systems (NeurIPS)*

#### **Grant Review**

*National Science Foundation (CCF, IIS)*  
*Israel Science Foundation*  
*Translational Data Analytics Institute*

**Reviewer for the Following Journals**

*Applied Computational and Harmonic Analysis*  
*Birkhauser Springer Series on Harmonic Analysis*  
*BIT Numerical Mathematics*  
*Digital Signal Processing*  
*Frontiers in Applied Mathematics and Statistics*  
*IEEE Geoscience and Remote Sensing Letters*  
*IEEE Journal of Selected Topics in Signal Processing*  
*IEEE Signal Processing Letters*  
*IEEE Transactions on Image Processing*  
*IEEE Transactions on Information Theory*  
*IEEE Transactions on Multimedia*  
*IEEE Transactions on Pattern Analysis and Machine Intelligence*  
*IEEE Transactions on Signal Processing*  
*Information and Inference: A Journal of the IMA*  
*International Journal of Computer Vision*  
*International Journal of Imaging Systems and Technology*  
*Journal of Machine Learning Research*  
*Operations Research*  
*Patter Recognition Letters*  
*Signal Processing*

**Reviewer for the Following Conferences**

*AAAI Conference on Artificial Intelligence (AAAI)*  
*Asilomar Conference on Signals, Systems, and Computers (Asilomar)*  
*Conference on the Mathematical Theory of Deep Neural Networks (DeepMath)*  
*European Conference on Computer Vision (ECCV)*  
*International Conference on Computer Vision (ICCV)*  
*IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*  
*IEEE International Conference on Communication Technology (ICCT)*  
*IEEE International Conference on Digital Signal Processing (DSP)*  
*IEEE Radar Conference (RadarConf)*  
*IEEE Int. Workshop on Computational Advances in Multi-Sensor Adaptive Processing (CAMSAP)*  
*International Conference on Learning Representations (ICLR)*  
*International Conference on Machine Learning (ICML)*  
*Neural Information Processing Systems (NeurIPS)*  
*Signal Processing with Adaptive Sparse Structured Representations (SPARS)*

**Conference Co-Organizer**

1. The First *Conference on Parsimony and Learning (CPAL)*, March 2025. (Publication Chair)
2. Conference on the Mathematical Theory of Deep Neural Networks, November 2024.
3. The First *Conference on Parsimony and Learning (CPAL)*, January 2024. (Publication Chair)

**Workshop and Conference Session Organizer**

1. SIAM Conference on Mathematics of Data Science (MDS24) — Mini-symposium on *Mathematical Principles in Foundation Models*, Atlanta, GA, U.S., October 2024 (with Sam Buchanan).
2. The 3rd Workshop on *Seeking Low-dimensionality in Deep Neural Networks (SlowDNN)*, January 2023.
3. SIAM Conference on Mathematics of Data Science (MDS22) — Mini-symposium on *Deep Learning with Low-Dimensional Models*, San Diego, CA, U.S., September 2022 (with Qing Qu and Chong You).

4. The 2nd Workshop on *Seeking Low-dimensionality in Deep Neural Networks (SlowDNN)*, November 2021 (with Yuejie Chi, Yi Ma, Qing Qu, Saiprasad Ravishankar, Jeremias Sulam, Atlas Wang, and Chong You)
5. IEEE Workshop on *Seeking Low-dimensionality in Deep Neural Networks (SlowDNN)*, November 2020 (with Yi Ma, Qing Qu, Jeremias Sulam, Atlas Wang, and Chong You)
6. SIAM Conference on Imaging Science — Minisymposium on *Machine Learning Meets Imaging Science*, Toronto, Ontario, Canada, July 2020 (with Tingran Gao and Qing Qu).
7. SIAM Conference on Mathematics of Data Science (MDS20) — Mini-symposium on *Recent Advances in Optimization Methods for Signal Processing and Machine Learning*, Cincinnati, Ohio, U.S., May 2020 (with Shuyang Ling and Qing Qu).

### **University Service**

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2023 CQISE Postdoctoral Fellow Program Search Committee, OSU

### **College Service**

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2021-2022 RSECS JEDI committee member, DU  
 2020-2022 IEEE Student Branch Faculty Supervisor, DU

### **Department Service**

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2025 Graduate Visit Day Committee, OSU  
 2023-2024 X+AI Committee, OSU  
 2022-2025 Graduate Admission Committee, OSU  
 2021 Faculty Search Committee for CS Tenure-Track Faculty (Assistant Professor), DU  
 2021 Faculty Search Committee for ECE Tenure-Track Faculty (all ranks), DU  
 2020-2022 ECE Graduate Admissions Committee, DU

### **Educational Experience**

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We developed “STEM in a Box” projects (2021) related to sensors, circuits, physics, and environment for Scouts-Denver who will send kits to schools around the Denver Metro area with a focus on campuses that serve mostly lower-income families, and presented lessons and activities related to signal filtering, movie recommendation systems, Google PageRank, and signal and video enhancement at the Mines Tech Camp/Discover STEM summer outreach program for middle school students (2014-2016), the Creating Technology program for high school girls (2015), and the Rocky Mountain Camp summer camp for dyslexic kids (2015-2016).