Wei Zhu

Contact Information

Department of Mathematics and Statistics
University of Massachusetts Amherst
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Education

University of California, Los Angeles 2012-2017

Ph.D. in Applied Mathematics (advisor: Stanley Osher)

Tsinghua University 2008-2012

B.S. in Mathematics

Employment

Department of Mathematics and Statistics, UMass Amherst 2020-present

Assistant Professor

Department of Mathematics, Duke University 2017-2020

Research Assistant Professor (mentor: Ingrid Daubechies)

Research Interests

Mathematical theory of data science and machine learning, structure-preserving (scientific) machine learning, optimization, applied harmonic analysis, applied probability, scientific computing, PDE and dynamical systems, computer vision and image processing.

External Grants

- **PI**. Air Force Young Investigator Program (YIP), *Structure-preserving and discovery in scientific machine learning*, $449,540, 2024 - 2027.
- **co-I**. NIH R01, *A novel approach of age-grading of mosquitoes using SERS and machine learning models*, $1,917,579, 2023 - 2028, (PI: Lili He at UMass Amherst).
- **PI**. NSF DMS-2244976, *CDS&E: Robust symmetry-preserving machine learning: theory and application*, $160,000, 2023 - 2026.
- **PI**. NSF DMS-2140982, *CDS&E EAGER Grant*, $103,360, 2021 - 2024.
- **PI**. NSF DMS-1952992 and DMS-2052525, *CDS&E: Applied geometry and harmonic analysis in deep learning regularization: theory and applications*, $155,000, 2020 - 2024.

Internal Grants

- **co-PI**. Institute for Applied Life Sciences (IALS) Midigrant: *Quantification of bacterial contamination levels on surfaces*, $15,000, 2023, (PI: Lili He at UMass Amherst).

Other Awards

- Air Force Young Investigator Program (YIP) Award 2024
- Pacific Journal of Mathematics Dissertation Prize 2017
- SIAM Early Career Travel Award 2017
- NSF-CBMS Travel Support Award 2016
- Fellowship in the Tsinghua Xuetang Talents Program 2010-2012

Publications

[1] Chen, Z. and **Zhu, W.** "On the implicit bias of linear equivariant steerable networks." *Neural Information Processing Systems (NeurIPS)*, 2023.

[2] Chen, Z., Katsoulakis, M., Rey-Bellet, L., and **Zhu, W.** "Sample complexity of probability divergences under group symmetry." In *International Conference on Machine Learning (ICML)*, pp. 4713-4734. PMLR, 2023.

[3] **Zhu, W.**, Zhang, H., and Kevrekidis, P.G. "Machine learning of independent conservation laws through neural deflation." *Phys. Rev. E*, 2023.

[4] Saqlain, S., **Zhu, W.**, Charalampidis, E.G. and Kevrekidis, P.G. "Discovering governing equations in discrete systems using PINNs." *Communications in Nonlinear Science and Numerical Simulation*: 107498, 2023.

[5] Gao, Z., Harrington, L., **Zhu, W.**, Barrientos, L., Alfonso-Parra, C., Avila, F., Clark, J., and He, L. "Accurate age-grading of field-collected mosquitoes reared under ambient conditions using surface-enhanced Raman spectroscopy and artificial neural networks." *Journal of Medical Entomology*, 2023.

[6] Birrell, J., Katsoulakis, M.A., Rey-Bellet, L. and **Zhu, W.** "Structure-preserving GANs." In *International Conference on Machine Learning (ICML), PMLR 162*:1982-2020, 2022.

[7] Gao, L., Lin, G., and **Zhu, W.** "Deformation robust roto-scale-translation equivariant CNNs." *Transactions on Machine Learning Research (TMLR)*, 2022.

[8] **Zhu, W.**, Khademi, W., Charalampidis, E.G. and Kevrekidis, P.G. "Neural networks enforcing physical symmetries in nonlinear dynamical lattices: The case example of the Ablowitz-Ladik model." *Physica D: Nonlinear Phenomena, 434*, p.133264, 2022.

[9] **Zhu, W.**, Qiu, Q., Calderbank, R., Sapiro, G. and Cheng, X. "Scaling-translation-equivariant networks with decomposed convolutional filters." *Journal of Machine Learning Research (JMLR), 23*(68), pp.1-45, 2022.

[10] Wang, B., Lin, A., Yin, P., **Zhu, W.**, L Bertozzi, A. and J Osher, S. "Adversarial defense via the data-dependent activation, total variation minimization, and adversarial training." *Inverse Problems & Imaging*, 2020.

[11] **Zhu, W.**, Shi, Z., and Osher, S. "Low dimensional manifold model in hyperspectral image reconstruction." *Advances in Computer Vision and Pattern Recognition*, 2020.

[12] **Zhu, W.**, Qiu, Q., Wang, B., Lu, J., Sapiro, G. and Daubechies, I. "Stop memorizing: A data-dependent regularization framework for intrinsic pattern learning." *SIAM Journal on Mathematics of Data Science, 1*(3), pp.476-496, 2019.

[13] Wu, Z., **Zhu, W.**, Chanussot, J., Xu, Y. and Osher, S. "Hyperspectral anomaly detection via global and local joint modeling of background." *IEEE Transactions on Signal Processing, 67*(14), pp.3858-3869, 2019.

[14] Wang, B., Luo, X., Li, Z., **Zhu, W.**, Shi, Z. and Osher, S. "Deep neural nets with interpolating function as output activation." *Neural Information Processing Systems (NeurIPS)*, 2018.

[15] **Zhu, W.**, Qiu, Q., Huang, J., Calderbank, R., Sapiro, G. and Daubechies, I. "LDMNet: Low dimensional manifold regularized neural networks." *In Proceedings of the IEEE conference on computer vision and pattern recognition (CVPR)* (pp. 2743-2751), 2018.

[16] **Zhu, W.**, Wang, B., Barnard, R., Hauck, C.D., Jenko, F. and Osher, S. "Scientific data interpolation with low dimensional manifold model." *Journal of Computational Physics, 352*, pp.213-245, 2018.

[17] **Zhu, W.**, Shi, Z. and Osher, S. "Scalable low dimensional manifold model in the reconstruction of noisy and incomplete hyperspectral images." *In 2018 9th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS)* (pp. 1-5). IEEE, 2018.

[18] Shi, Z., Osher, S. and **Zhu, W.** "Generalization of the weighted nonlocal laplacian in low dimensional manifold model." *Journal of Scientific Computing, 75*(2), pp.638-656, 2017.

[19] **Zhu, W.**, Chayes, V., Tiard, A., Sanchez, S., Dahlberg, D., Bertozzi, A.L., Osher, S., Zosso, D. and Kuang, D. "Unsupervised classification in hyperspectral imagery with nonlocal total variation and primal-dual hybrid gradient algorithm." *IEEE Transactions on Geoscience and Remote Sensing, 55*(5), pp.2786-2798, 2017.

[20] Shi, Z., Osher, S. and **Zhu, W.** "Weighted nonlocal laplacian on interpolation from sparse data." *Journal of Scientific Computing, 73*(2), pp.1164-1177, 2017

[21] Chayes, V., Miller, K., Bhalerao, R., Luo, J., **Zhu, W.**, Bertozzi, A.L., Liao, W. and Osher, S. "Pre-processing and classification of hyperspectral imagery via selective inpainting." *In 2017 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)* (pp. 6195-6199). IEEE, 2017.

[22] Osher, S., Shi, Z. and **Zhu, W.** "Low dimensional manifold model for image processing." *SIAM Journal on Imaging Sciences, 10*(4), pp.1669-1690, 2017.

Preprints

[23] Chen, Z., Katsoulakis, M., Rey-Bellet, L., and **Zhu, W.** "Statistical guarantees of group-invariant GANs." 2023.

[24] Li, W., Zhang, Y., He, L., and **Zhu, W.** "Machine learning-assisted bacterial cell quantification in low-magnification microscopic imagery." 2023.

[25] **Zhu, W.** and Daubechies, I. "Constructing curvelet-like bases and low-redundancy frames." 2019.

Teaching

University of Massachusetts Amherst (Instructor)

Statistics I	Fall 2023
Mathematical Theory of Machine Learning Part II	Spring 2023
Mathematical Theory of Machine Learning Part I	Fall 2022
Introduction to Modern Analysis I	Fall 2022
Introduction to Modern Analysis II	Spring 2022
Introduction to Modern Analysis I	Fall 2021
Introduction to Foundations of Data Science	Summer 2021
Introduction to Partial Differential Equations	Spring 2021
Statistics I	Fall 2020

Duke University (Instructor)

Elementary Differential Equations	Fall 2019
Elementary Differential Equations	Spring 2019
Elementary Differential Equations	Fall 2018

University of California, Los Angeles (Course Assistant)

Applied Numerical Methods	Spring 2017
Linear and Nonlinear Systems of Differential Equations	Fall 2016
Numerical Linear Algebra for Data Analysis	Winter 2016
Optimization	Fall 2015
Applied Numerical Methods	Fall 2015
Differential Equations	Spring 2015
Discrete Structures	Spring 2015
Calculus of Several Variables	Winter 2015
Integration and Infinite Series	Fall 2014
Differential and Integral Calculus	Winter 2014

Mentorship

Graduate student mentoring

- Shaoxuan Chen (Ph.D. student, statistics) 2022-present

Postdoc mentoring

- Ziyu Chen 2022-present

Undergraduate research mentoring

- Scott Wang (Amherst College) 2023-present
- Wenhan Li (UMass) 2022-present
- Jack Champagne (UMass; next position: master at CMU) 2021-2023
- Sheikh Saqlain (UMass; next position: Ph.D. at NYU) 2022-2023
- Vivek Chakrabhavi (UMass; next position: Ph.D. at UPenn) 2022-2023
- Gregory Turnberg (UMass) 2022
- Yanzhe Hu (UMass; next position: master at NYU) 2022
- Xingyu Zhu (UMass) 2022
- Ashley Kwon (Duke) 2019
- Ivy Shi (Duke) 2017
- Victoria Chayes (UCLA; next position: Ph.D. at Rutgers) 2016
- Jiajie Luo (UCLA; next position: Ph.D. at UCLA) 2016
- Kevin Miller (UCLA; next position: Ph.D. at UCLA) 2016
- Rasika Bhalerao (UCLA; next position: Ph.D. at NYU) 2016

Exam and Thesis committee

- Su Yang (UMass, Ph.D. student), member of oral exam committee.
- Shaoxuan Chen (UMass, Ph.D. student), chair of oral exam committee.
- Sheikh Saqlain (UMass, undergrad), co-chair of Honors Thesis committee.
- Hyemin Gu (UMass, Ph.D. student), member of oral exam committee.
- Georgios Tsolias (UMass, Ph.D. student), member of dissertation committee.
- Ryan Ross (UMass, Ph.D. student), member of oral exam committee.

Informal mentoring of/working with postdocs

- Jeremiah Birrell (UMass)
- Elisa Negrini (UCLA)

Invited Talks

- International Conference on Scientific Computation And Differential Equations, National University of Singapore, July 2024.
- North American High Order Methods Conference, Dartmouth College, June 2024.
- SIAM Conference on Imaging Science, Atlanta, Georgia, May 2024.
- Computational and Applied Math Seminar, Tufts University, April 2024.
- Department Seminar, Department of Applied Mathematics and Statistics, Johns Hopkins University, February 2024.
- Colloquium, Department of Mathematics, University of Maryland, January 2024.
- Colloquium, Department of Mathematics, Georgia Institute of Technology, January 2024.
- Applied and Computational Math Seminar, Dartmouth College, January 2024.
- Boston Symmetry Day, Massachusetts Institute of Technology, November 2023.
- Applied and Computational Math Seminar, University of California Irvine, October 2023.
- Level Set Meeting, University of California Los Angeles, August 2023.
- Learning Learning Seminar, University of Massachusetts, Amherst, April 2023.
- Math Machine Learning Seminar, Max Planck Institute for Mathematics in the Sciences and UCLA, April 2023.
- Departmental Seminar, South Dakota State University, February 2023.
- Machine Learning and Differential Equations Seminar, Tsinghua University, November 2022.
- One World MINDS Seminar, November 2022.
- Data Science Seminar, University of California Santa Barbara, October 2022.
- AMS Fall Eastern Sectional Meeting, University of Massachusetts, Amherst, October 2022.
- SIAM Conference on Mathematics of Data Science, September 2022.
- International Conference on Machine Learning (ICML), July 2022.
- SIAM Conference on Imaging Science, March 2022.
- Applied & Computational Math Series , Georgia Institute of Technology, March 2022.
- Mathematics in Imaging, Data and Optimization, Rensselaer Polytechnic Institute, March 2022.
- Reading Seminar on Mathematics of Machine Learning , University of Massachusetts, Amherst, September 2021.
- SIAM Southeastern Atlantic Sectional Conference, Auburn University, September 2021.

- Applied Math Seminar, University of Texas, Austin, September 2021.
- Conference on Mathematics for Nonstationary Signals and applications in Geophysics and other fields (NoSAG), University of L'Aquila, July 2021.
- Seminar on Mathematics of Data and Decisions at Davis, Department of Mathematics, University of California, Davis, May 2021.
- AMS Fall Eastern Sectional Meeting, Pennsylvania State University, October 2020.
- PhILMs Webinar Series, Pacific Northwest National Laboratory, June 2020.
- CCMA Deep Learning Seminar, Department of Mathematics, Pennsylvania State University, April 2020.
- Numerical Analysis and Scientific Computing Seminar, Department of Mathematics, Emory University, April 2020.
- CCAM Seminar, Department of Mathematics, Purdue University, February 2020.
- Modeling and Comp Seminar, Department of Mathematics, University of Arizona, January 2020.
- Special Colloquium, Department of Mathematics, National University of Singapore, January 2020.
- Special Colloquium, Department of Mathematics, University of California, Santa Barbara, January 2020.
- Special Colloquium, Department of Mathematics and Statistics, University of Massachusetts, Amherst, December 2019.
- Special Colloquium, Department of Mathematics, University of Melbourne, December 2019.
- Special Seminar, Courant Institute of Mathematical Sciences, New York University, December 2019.
- Math Colloquium, Department of Mathematics, University of Tennessee, Knoxville, December 2019.
- Math Colloquium, Department of Mathematics, University of South Carolina, December 2019.
- Applied and Computational Mathematics Seminar, Department of Mathematics, University of Minnesota Twin Cities, November 2019.
- Scientific Computing Seminar, Division of Applied Mathematics, Brown University, October 2019.
- Applied Math Seminar, Department of Mathematics, Georgia Institute of Technology, September 2019.
- Level-set Collective, Department of Mathematics, University of California, Los Angeles, July 2019.
- 2019 Joint Mathematics Meetings (JMM 2019), Baltimore MD, January 2019.
- Applied Math Seminar, Department of Mathematics, Tsinghua University, December 2018.

- PKU Young Forum on Applied Mathematics and Statistics, Department of Mathematics, Peking University, December 2018.
- Conference on Computer Vision and Pattern Recognition (CVPR 2018), Salt Lake City UT, June 2018.
- Applied Math Colloquium, Department of Mathematics, Rensselaer Polytechnic Institute, April 2018.
- SIAM Southeastern Atlantic Section, Chapel Hill NC, March 2018.
- Computational and Applied Mathematics Colloquium, Department of Mathematics, Pennsylvania State University, February 2018.
- IPAM Workshop on New Deep Learning Techniques, University of California Los Angeles, February 2018.
- 2017 SIAM Annual Meeting, Pittsburgh PA, July 2017.
- Data Dialogue at Information Initiative at Duke, Duke University, January 2017.
- Applied Math Seminar, Department of Mathematics, Shanghai Jiaotong University, September 2016.
- Level-set Collective, Department of Mathematics, University of California, Los Angeles, June 2016.
- Level-set Collective, Department of Mathematics, University of California, Los Angeles, August 2015.

Professional Services

Panel Member

- NSF 2021, 2023

Conference Reviewer

- NeurIPS
- ICML
- ICLR
- CVPR
- ECCV
- ICCV
- AAAI

Journal Referee

- Applied and Computational Harmonic Analysis
- Communications on Applied Mathematics and Computation
- Information and Inference: A Journal of IMA
- Inverse Problems and Imaging
- Multiscale Modeling and Simulation
- IEEE Transactions on Geoscience and Remote Sensing
- IEEE Transactions on Image Processing
- IEEE Transactions on Signal Processing
- Journal of Scientific Computing
- Journal of Visual Communication and Image Representation
- Pattern Recognition
- SIAM Journal on Imaging Sciences
- SIAM Journal on Applied Mathematics
- Transactions on Machine Learning Research