Jonathan W. Siegel

Texas A&M University **Department of Mathematics Blocker Building** College Station, TX 77840 This CV is up to date as of June 2024.

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EDUCATION

University of California at Los Angeles Ph.D. in Mathematics Advisor: Russel E. Caflish Thesis: "Accelerated First-Order Optimization with Orthogonality Constraints"

University of California at Santa Cruz

B.Sc. (Honors) in Mathematics

ACADEMIC APPOINTMENTS

Assistant Professor Texas A&M University

Assistant Research Professor Pennsylvania State University

Postdoctoral Scholar

Pennsylvania State University

RESEARCH PAPERS

Journal Articles

- 1. Sharp Lower Bounds on the Manifold Widths of Sobolev and Besov Spaces. Journal of Complexity 101884, 2024.
- 2. Entropy-based convergence rates of greedy algorithms. Mathematical Models and Methods in Applied Sciences 34(05):779-802, 2024. With Yuwen Li.
- 3. Optimal Approximation Rates for Deep ReLU Neural Networks on Sobolev and Besov Spaces. Journal of Machine Learning Research 24.357:1-52, 2023.
- 4. Greedy Training Algorithms for Neural Networks and Applications to PDEs. Journal of Computational Physics 484:112084, 2023. With Qingguo Hong, Xianlin Jin, Wenrui Hao, and Jinchao Xu.

2022-present College Station, TX

2021-2022 University Park, PA

2018-2021 University Park, PA

Los Angeles, CA

2013-2018

2009-2013

Santa Cruz, CA

- 5. Extended Regularized Dual Averaging Methods for Stochastic Optimization. *Journal of Computational Mathematics* 41(3):525-541, 2023. With Jinchao Xu.
- 6. Sharp Bounds on the Approximation Rates, Metric Entropy, and *n*-widths of Shallow Neural Networks. *Foundations of Computational Mathematics* 1-57, 2022. With Jinchao Xu.
- 7. Characterization of the Variation Spaces Corresponding to Shallow Neural Networks. Constructive Approximation 1-24, 2023. With Jinchao Xu.
- 8. Uniform Approximation Rates and Metric Entropy of Shallow Neural Networks. *Research in the Mathematical Sciences* 9.3:1-21, 2022. With Limin Ma and Jinchao Xu.
- 9. Optimal Convergence Rates for the Orthogonal Greedy Algorithm. *IEEE Transactions on Information Theory* 68.5:3354-3361, 2022. With Jinchao Xu.
- Extensible Structure-Informed Prediction of Formation Energy with Improved Accuracy and Usability employing Neural Networks. *Computational Materials Science* 208:111254, 2021. With Adam Krajewski, Zi-Kui Liu, and Jinchao Xu.
- High-Order Approximation Rates for Shallow Neural Networks with Cosine and ReLU^k Activation Functions. Applied and Computational Harmonic Analysis 58:1-26, 2022. With Jinchao Xu.
- 12. Approximation Rates for Neural Networks with General Activation Functions. Neural Networks 128:313-321, 2020. With Jinchao Xu.
- 13. Accuracy, Efficiency and Optimization of Signal Fragmentation. *Multiscale Modeling and Simulation* 18(2):737–757, 2020. With Russel Caffisch and Hung Hsu Chou
- 14. Accelerated Optimization with Orthogonality Constraints. Journal of Computational Mathematics 39(2):207–226, 2020.
- 15. Compact Support of L^1 Penalized Variational Problems. Communications in Mathematical Sciences 15(6):1771-1790, 2017. With Omer Tekin.

Conference Papers

 Equivariant Frames and the Impossibility of Continuous Canonicalization. to appear at ICML 2024. With Nadav Dym and Hannah Lawrence Preprint available at: https://arxiv.org/abs/2402.16077

After First Revision

- Sharp Convergence Rates for Matching Pursuit. Submitted to IEEE Transactions on Information Theory, 2023. With Jason Klusowski Preprint available at: https://arxiv.org/abs/2307.07679
- Weighted variation spaces and approximation by shallow ReLU networks. *Submitted to Applied and Computational Harmonic Analysis*, 2023. With Ronald DeVore, Robert Nowak and Rahul Parhi

Preprint available at: https://arxiv.org/abs/2307.15772

Under Review

- Convergence and Error Control of Consistent PINNs for Elliptic PDEs. Submitted to IMA Journal of Numerical Analysis, 2024. With Andrea Bonito, Ronald DeVore, and Geurgana Petrova. Preprint available at: https://arxiv.org/abs/2406.09217
- Efficient Structure-Informed Featurization and Property Prediction of Ordered, Dilute, and Random Atomic Structures. Submitted to Computational Materials Science, 2024. With Adam Krajewski and Zi-Kui Liu. Preprint available at: https://arxiv.org/abs/2404.02849
- Optimal Approximation of Zonoids and Uniform Approximation by Shallow Neural Networks. Submitted to Constructive Approximation, 2023. Preprint available at: https://arxiv.org/abs/2307.15285
- Achieving acceleration despite very noisy gradients. *Submitted to NeurIPS*, 2024. With Kanan Gupta and Stephan Wojtowytsch Preprint available at: https://arxiv.org/abs/2302.05515
- Sharp Lower Bounds on Interpolation by Deep ReLU Neural Networks at Irregularly Spaced Data. Submitted to Journal of Approximation Theory, 2023. Preprint available at: https://arxiv.org/abs/2302.00834
- On the Activation Function Dependence of the Spectral Bias of Neural Networks. *Submitted to IEEE Transactions on Neural Networks and Learning Systems*, 2023. With Qingguo Hong, Qingyang Tan and Jinchao Xu Preprint available at: https://arxiv.org/abs/2208.04924

Preprints

- Training Sparse Neural Networks using Compressed Sensing, 2021. With Jianhong Chen, Pengchuan Zhang and Jinchao Xu. Preprint available at: https://arxiv.org/abs/2008.09661
- Accelerated First-Order Methods: Differential Equations and Lyapunov Functions, 2019. Preprint available at: https://arxiv.org/abs/1903.05671

GRANTS

| Penn State Institute for CyberScience Seed Grant (co-PI) | 2018-2019 |
|--|---------------|
| PIs: Jinchao Xu and Zi-Kui Liu | |
| "Deep Learning for CALPHAD Database Development and Uncertainty Quantificati | ion" \$35,000 |
| | |
| NSF DMS-2111387 (co-PI) | 2021-2024 |

PI: Jinchao Xu "Comparative Study of Finite Element and Neural Networks Discretizations for Partial Differential Equations" \$550,000

NSF DMS-2216799 (PI)

"US Participation at the Twenty-sixth International Domain Decomposition Conference" \$15,000

2022

| NSF CCF-2205004 (co-PI) PI: Jia Li | 2022-2025 |
|--|---|
| "CIF: Small: Interpretable Machine Learning based on Deep Neural Networ Perspective" | ks: A Source Coding \$600,000 |
| SciTech Services (PI) "Three-Dimensional Compression of Spatial-Spectral Information Using Manique" | 2024-2025 chine Learning Tech- \$75,263 |
| KAUST OFP 2023 (Sub-award) | 2024-2025 |
| PI: Jinchao Xu "Multilevel Training Algorithms for Scientific Computing" | \$17,090 |
| TEACHING EXPERIENCE | |
| Texas A&M University Instructor Math 689 - Principle of Deep Learning (Graduate Course) | Fall 2023 College Station, TX |
| Texas A&M University Instructor Math 667 - Foundations and Methods of Approximation (Graduate Course) | Spring 2023 College Station, TX |
| Texas A&M University Instructor Math 308H - Honors Differential Equations | Fall 2022 College Station, TX |
| Pennsylvania State University Instructor Math 141 - Integral Calculus | Fall 2021 University Park, PA |
| Pennsylvania State University <i>Co-Instructor</i> Math 555 - Optimization Theory (Graduate Course) | Spring 2021 University Park, PA |
| Pennsylvania State University Instructor Math 140 - Differential Calculus | Fall 2020 University Park, PA |
| Pennsylvania State University Instructor Math 251 - Differential Equations Math 251H - Honors Differential Equations | Spring 2020 University Park, PA |

| Pennsylvania State University Instructor Math 141 - Integral Calculus | Fall 2019 University Park, PA |
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| Pennsylvania State University/Peking University <i>Co-Instructor</i> Math 497 - Introduction to Deep Learning | Summer 2019 Beijing, China |
| Pennsylvania State University Instructor Math 141 - Integral Calculus | Fall 2018 University Park, PA |
| University of California, Los Angeles Teaching Assistant | 2014-2017 Los Angeles, CA |

Math 110B - Finite Group Theory
INVITED SEMINAR. AND CONFERENCE TALKS

Math 32B - Integral Vector Calculus Math 32A - Differential Vector Calculus

| Pennsylvania State University Computation and Applied Mathematics Seminar | May 21, 2024 |
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| Oberwolfach Workshop Mathematics of Entropic AI in the Natural Sciences | April 9, 2024 |
| Texas A& M University AI, ML, and Health Collaborations Workshop | March 21, 2024 |
| National Yang Ming Chiao Tung University Webinar on Scientific Machine Learning | November 3, 2023 |
| Steklov Institute Conference in Honor of Vladimir Temlyakov | November 1, 2023 |
| Southern Methodist University Math Colloquium | October 4, 2023 |
| Brigham Young University Applied Math Seminar | September 21, 2023 |
| Duke University Workshop on Computational and Data Science | August 17, 2023 |
| Duke University | August 15, 2023 |

| Summer School on Computational and Data Science | |
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| Morgan State University CBMS Conference on Deep Learning and Numerical PDEs | June 22, 2023 |
| Texas A&M University Inaugural CAMDA Conference | May 23, 2023 |
| University of Texas at El Paso Applied Mathematics Seminar | February 17, 2023 |
| SUNY Albany Data Science Seminar | January 23, 2023 |
| Brown University Crunch Seminar on Scientific Computing | December 23, 2022 |
| Texas A&M University TAMIDS Seminar | December 8, 2022 |
| University of Oslo Scientific and Machine Learning Seminar | December 1, 2022 |
| King Abdullah University of Science and Technology (KAUST) Mathematics and Computational Science Seminar | November 22, 2022 |
| King Abdullah University of Science and Technology (KAUST) Conference on Scientific Computing and Machine Learning | November 15, 2022 |
| Texas State University SyDATA Symposium | September 30, 2022 |
| Texas A&M University CAMDA Seminar | August 31, 2022 |
| Czech Technical University in Prague 27th International Conference on Domain Decomposition Methods, Invited | July 26, 2022 Plenary Talk |
| Princeton University Wilks Seminar | May 16, 2022 |
| Georgia Institute of Technology Applied and Computational Mathematics (ACM) Seminar | April 4, 2022 |
| Illinois Institute of Technology | January 21, 2022 |

| Mathematics Department Colloquium | |
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| Texas A&M University Mathematics Department Colloquium | December 6, 2021 |
| University of South Carolina Mathematics Department Colloquium | November 29, 2021 |
| Rensselaer Polytechnic Institute Mathematics in Imaging, Data and Optimization Seminar | October 6, 2021 |
| RWTH Aachen Applied Mathematics Group Lunch Seminar | October 4, 2021 |
| ETH Zurich FoMICS Seminar Talk and Lecture | June 2, 2021 |
| University of Texas, Austin Applied Mathematics Seminar | May 21, 2021 |
| University of California, San Diego CCoM Seminar | May 11, 2021 |
| Purdue University Mathematical Data Science Webinar | May 10, 2021 |
| University of Notre Dame ACMS Applied Mathematics Seminar | April 15, 2021 |
| University of California, Irvine Computational Mathematics Seminar | March 15, 2021 |
| California Institute of Technology CMX (Computational Mathematics) Seminar | February 17, 2021 |
| Pennsylvania State University CCMA Workshop on Mathematical Machine Learning and Applications | December 15, 2020 |

INVITED MINI-SYMPOSIUM TALKS

North American High Order Methods Conference at Dartmouth June 18, 2024 Design and analysis of machine learning algorithms inspired by traditional numerical methods

| AMS Sectional Meeting at the UW Milwaukee | |
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| Recent Advances in Numerical PDE Solvers by Deep Learning | |

April 20, 2024

| AMS Sectional Meeting at Florida State University Mathematical Advances in Scientific Machine Learning | March 23, 2024 |
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| Foundations of Computational Mathematics Conference Approximation Theory Session | June 19, 2023 |
| Copper Mountain Conference on Multigrid Methods Artificial intelligence and multilevel methods | April 17, 2023 |
| SIAM Conference on the Mathematics of Data Science Recent Advances in Machine Learning and Optimization | September 27, 2022 |
| SIAM Conference on Uncertainty Quantification Recent Advances in Machine Learning and Data-Driven Methods for Physica neering | April 12, 2022 l Sciences and Engi- |
| AMS Fall Western Sectional Meeting Special Session on Theoretical and Applied perspectives in Machine Learning | October 23, 2021 |
| SIAM Conference on Analysis of PDEs Mathematics of Machine Learning Methods for PDEs | March 16, 2021 |
| Kunming, China International Multigrid Conference (IMG) | August 15, 2019 |

SERVICE

Students Advised

- Jianhong Chen, Penn State Graduate Student, 2019-2020 (co-advised)
- Xianlin Jin, Peking University Graduate student, 2021-present (co-advised)
- Kanan Gupta, Texas A&M University Graduate Student, 2022-present (co-advised)
- Jiyoung Park, Texas A&M University Graduate Student, 2023-present

Conferences Co-Organized

• CCMA Workshop on Mathematical Machine Learning and Applications, December 14-16, 2020.

Seminars Co-Organized

• Computational and Applied Mathematics (CAM) Colloquium at Penn State, Fall 2020-Fall 2021

Ad-Hoc Reviewer for

• Journals: Mathematical Programming, Neural Networks, Numerical Algorithms, Calculus of Variations and Partial Differential Equations, Expert Systems with Applications, IEEE Transac-

tions on Neural Networks and Learning Systems, SIAM Journal on Optimization, SIAM Journal on Numerical Analysis, SIAM Journal on Scientific Computing, SIAM Journal on Mathematics of Data Science, Journal of Machine Learning Research, Analysis and Applications, Annals of Statistics

• Conferences: AISTATS, CAMDA Conference Proceedings

AWARDS AND SCHOLARSHIPS

| University of California, Los AngelesPacific Journal of Mathematics Dissertation Award | 2018 | | |
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| University of California, Los Angeles University of California Regents Fellow University of California, Santa Cruz Stephen M. Palais Award University of California, Santa Cruz Putnam Mathematical Competition Honorable Mention | 2013-2014 2012 2011 | | |
| | | AFFILIATIONS | |
| | | American Mathematical Association (AMS) | 2021-present |
| Society of Industrial and Applied Mathematicians (SIAM) | 2021-present | | |
| Institute of Electrical and Electronics Engineers (IEEE) | 2023-present | | |

INDUSTRY EXPERIENCE

Google Intern

Mountainview, CA

I worked with the Network Architecture team on improving the efficiency of a Monte Carlo network reliability simulation. Specifically, I implemented importance sampling, which reduced the number of samples required by a factor of 3.

Google Intern

Los Angeles, CA

I worked with the Budgetplanner Team (a division working on advertisement). I built a data processing pipeline that collected and processed data which was scattered across multiple relational databases to create training data for a machine learning model. Then I used TensorFlow to design and test multiple machine learning models on the resulting dataset.

TECHNICAL STRENGTHS

Programming Skills: C/C++, Java, Matlab, Latex, Python

June 12, 2017-September 1, 2017

June 6, 2016-August 26, 2016