# Jonathan W. Siegel

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## EDUCATION

**University of California at Los Angeles** 2013-2018
*Ph.D. in Mathematics* Los Angeles, CA
Advisor: Russel E. Caflish
Thesis: "Accelerated First-Order Optimization with Orthogonality Constraints"

**University of California at Santa Cruz** 2009-2013
*B.Sc. (Honors) in Mathematics* Santa Cruz, CA

## ACADEMIC APPOINTMENTS

**Assistant Professor** 2022-present
*Texas A&M University* College Station, TX

**Assistant Research Professor** 2021-2022
*Pennsylvania State University* University Park, PA

**Postdoctoral Scholar** 2018-2021
*Pennsylvania State University* University Park, PA

## RESEARCH PAPERS

### Published

- 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.
- Extended Regularized Dual Averaging Methods for Stochastic Optimization. *Journal of Computational Mathematics* 41(3):525-541, 2023. With Jinchao Xu.
- 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.
- Characterization of the Variation Spaces Corresponding to Shallow Neural Networks. *Constructive Approximation* 1-24, 2023. With Jinchao Xu.
- 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.

- 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 $\mathrm{ReLU}^k$ Activation Functions. *Computational and Applied Harmonic Analysis* 58:1-26, 2022. With Jinchao Xu.
- Approximation rates for neural networks with general activation functions. *Neural Networks* 128:313-321, 2020. With Jinchao Xu.
- Accuracy, Efficiency and Optimization of Signal Fragmentation. *Multiscale Modeling and Simulation* 18(2):737–757, 2020. With Russel Caflisch and Hung Hsu Chou
- Accelerated Optimization with Orthogonality Constraints. *Journal of Computational Mathematics* 39(2):207–226, 2020.
- Compact Support of $L^1$ Penalized Variational Problems. *Communications in Mathematical Sciences* 15(6):1771-1790, 2017. With Omer Tekin.

## After First Revision

- Optimal Approximation Rates for Deep ReLU Neural Networks on Sobolev Spaces. *Submitted to Journal of Machine Learning Research*, 2023.
  Preprint available at: https://arxiv.org/abs/2211.14400

## Under Review

- 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
- Optimal Approximation of Zonoids and Uniform Approximation by Shallow Neural Networks. *to be Submitted*, 2023.
  Preprint available at: https://arxiv.org/abs/2307.15285
- 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
- Achieving acceleration despite very noisy gradients. *Submitted to NeurIPS*, 2023. With Kanan Gupta and Stephan Wojtowytsch
  Preprint available at: https://arxiv.org/abs/2302.05515
- Entropy-based convergence rates of greedy algorithms. *Submitted to Mathematical Models and Methods in Applied Sciences*, 2023. With Yuwen Li

Preprint available at: https://arxiv.org/abs/2304.13332

- Sharp Lower Bounds on Interpolation by Deep ReLU Neural Networks at Irregularly Spaced Data. *Submitted to Machine Learning*, 2023.
  Preprint available at: https://arxiv.org/abs/2302.00834
- On the Activation Function Dependence of the Spectral Bias of Neural Networks. *Submitted to SIAM Journal on Scientific Computing*, 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
"Deep Learning for CALPHAD Database Development and Uncertainty Quantification" $35,000

**NSF DMS-2111387 (co-PI)** 2021-2024
"Comparative Study of Finite Element and Neural Networks Discretizations for Partial Differential Equations" $550,000

**NSF DMS-2216799 (PI)** 2022
"US Participation at the Twenty-sixth International Domain Decomposition Conference" $15,000

**NSF CCF-2205004 (co-PI)** 2022-2025
"CIF: Small: Interpretable Machine Learning based on Deep Neural Networks: A Source Coding Perspective" $600,000

## TEACHING EXPERIENCE

**Texas A&M University** Spring 2023
*Instructor* College Station, TX
Math 667 - Foundations and Methods of Approximation (Graduate Course)

**Texas A&M University** Fall 2022
*Instructor* College Station, TX
Math 308H - Honors Differential Equations

**Pennsylvania State University** Fall 2021
*Instructor* University Park, PA

Math 141 - Integral Calculus

**Pennsylvania State University** Spring 2021
*Co-Instructor* University Park, PA
Math 555 - Optimization Theory (Graduate Course)

**Pennsylvania State University** Fall 2020
*Instructor* University Park, PA
Math 140 - Differential Calculus

**Pennsylvania State University** Spring 2020
*Instructor* University Park, PA
Math 251 - Differential Equations
Math 251H - Honors Differential Equations

**Pennsylvania State University** Fall 2019
*Instructor* University Park, PA
Math 141 - Integral Calculus

**Pennsylvania State University/Peking University** Summer 2019
*Co-Instructor* Beijing, China
Math 497 - Introduction to Deep Learning

**Pennsylvania State University** Fall 2018
*Instructor* University Park, PA
Math 141 - Integral Calculus

**University of California, Los Angeles** 2014-2017
*Teaching Assistant* Los Angeles, CA
Math 32B - Integral Vector Calculus
Math 32A - Differential Vector Calculus
Math 110B - Finite Group Theory

## INVITED SEMINAR AND CONFERENCE TALKS

**Morgan State University** June 22, 2023
*CBMS Conference on Deep Learning and Numerical PDEs*

**Texas A&M University** May 23, 2023
*Inaugural CAMDA Conference*

**University of Texas at El Paso** February 17, 2023
*Applied Mathematics Seminar*

**SUNY Albany** January 23, 2023

*Data Science Seminar*

**Brown University** December 23, 2022
*Crunch Seminar on Scientific Computing*

**Texas A&M University** December 8, 2022
*TAMIDS Seminar*

**University of Oslo** December 1, 2022
*Scientific and Machine Learning Seminar*

**King Abdullah University of Science and Technology (KAUST)** November 22, 2022
*Mathematics and Computational Science Seminar*

**King Abdullah University of Science and Technology (KAUST)** November 15, 2022
*Conference on Scientific Computing and Machine Learning*

**Texas State University** September 30, 2022
*SyDATA Symposium*

**Texas A&M University** August 31, 2022
*CAMDA Seminar*

**Czech Technical University in Prague** July 26, 2022
*27th International Conference on Domain Decomposition Methods, Invited Plenary Talk*

**Princeton University** May 16, 2022
*Wilks Seminar*

**Georgia Institute of Technology** April 4, 2022
*Applied and Computational Mathematics (ACM) Seminar*

**Illinois Institute of Technology** January 21, 2022
*Mathematics Department Colloquium*

**Texas A&M University** December 6, 2021
*Mathematics Department Colloquium*

**University of South Carolina** November 29, 2021
*Mathematics Department Colloquium*

**Rensselaer Polytechnic Institute** October 6, 2021
*Mathematics in Imaging, Data and Optimization Seminar*

**RWTH Aachen** October 4, 2021

*Applied Mathematics Group Lunch Seminar*

**ETH Zurich** June 2, 2021
*FoMICS Seminar Talk and Lecture*

**University of Texas, Austin** May 21, 2021
*Applied Mathematics Seminar*

**University of California, San Diego** May 11, 2021
*CCoM Seminar*

**Purdue University** May 10, 2021
*Mathematical Data Science Webinar*

**University of Notre Dame** April 15, 2021
*ACMS Applied Mathematics Seminar*

**University of California, Irvine** March 15, 2021
*Computational Mathematics Seminar*

**California Institute of Technology** February 17, 2021
*CMX (Computational Mathematics) Seminar*

**Pennsylvania State University** December 15, 2020
*CCMA Workshop on Mathematical Machine Learning and Applications*

## INVITED MINI-SYMPOSIUM TALKS

**Foundations of Computational Mathematics Conference** June 19, 2023
*Approximation Theory*

**Copper Mountain Conference on Multigrid Methods** April 17, 2023
*Artificial intelligence and multilevel methods*

**SIAM Conference on the Mathematics of Data Science** September 27, 2022
*Recent Advances in Machine Learning and Optimization*

**SIAM Conference on Uncertainty Quantification** April 12, 2022
*Recent Advances in Machine Learning and Data-Driven Methods for Physical Sciences and Engineering*

**AMS Fall Western Sectional Meeting** October 23, 2021
*Special Session on Theoretical and Applied perspectives in Machine Learning*

**SIAM Conference on Analysis of PDEs** March 16, 2021

*Mathematics of Machine Learning Methods for PDEs*

**Kunming, China** August 15, 2019
*International Multigrid Conference (IMG)*

# SERVICE

## Students Co-Advised

- Jianhong Chen, Penn State Graduate Student, 2019-2020
- Xianlin Jin, Peking University Graduate student, 2021-present
- Kanan Gupta, Texas A&M University Graduate Student, 2022-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

- Mathematical Programming, Neural Networks, AISTATS, Numerical Algorithms, Calculus of Variations and Partial Differential Equations, Expert Systems with Applications, IEEE Transactions 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

# AWARDS AND SCHOLARSHIPS

**University of California, Los Angeles** 2018
- Pacific Journal of Mathematics Dissertation Award

**University of California, Los Angeles** 2013-2014
- University of California Regents Fellow

**University of California, Santa Cruz** 2012
- Stephen M. Palais Award

**University of California, Santa Cruz** 2011
- Putnam Mathematical Competition Honorable Mention

# AFFILIATIONS

American Mathematical Association (AMS) 2021-present
Society of Industrial and Applied Mathematicians (SIAM) 2021-present

## INDUSTRY EXPERIENCE

**Google Intern** June 6, 2016-August 26, 2016

*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** June 12, 2017-September 1, 2017

*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