# **SPENCER FREI**

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#### **RESEARCH INTERESTS**

Machine learning. Particular interest in understanding deep learning and its implications for statistical learning theory, non-convex optimization, & high-dimensional statistics.

# POSITIONS

Assistant Professor, Department of Statistics, UC Davis	Starting Fall 2023
<ul> <li>Postdoctoral Fellow, Simons Institute for the Theory of Computing, UC Berkeley</li> <li>— Mentors: Peter Bartlett and Bin Yu.</li> <li>— Part of the NSF/Simons Collaboration on the Theoretical Foundations of Deep Learning</li> </ul>	2021–present
Visiting Scientist, École polytechnique fédérale de Lausanne (EPFL), Switzerland — Hosted by Emmanuel Abbé.	Sep. & Oct. 2022
EDUCATION	
Ph.D, Statistics, UCLA — Co-advisors: Quanquan Gu and Ying Nian Wu; committee members: Arash Amini ar — Thesis: Statistical learning with neural networks trained by gradient descent.	2015–2021 nd Qing Zhou.
MSc., Mathematics, University of British Columbia, Vancouver — Advisor: Edwin A. Perkins. — Thesis: A lower bound for the critical probability in range- <i>R</i> bond percolation.	2013–2015
BSc., Mathematics, McGill University, Montréal — First class honours.	2009–2013

# **PUBLICATIONS AND PREPRINTS**

- 1. Ruiqi Zhang, **Spencer Frei**, and Peter L. Bartlett. Trained transformers learn linear models in-context. *Preprint*, arXiv:2306.09927.
- 2. **Spencer Frei\***, Gal Vardi\*, Peter L. Bartlett, and Nathan Srebro. Benign overfitting in linear classifiers and leaky ReLU networks from KKT conditions for margin maximization. *Conference on Learning Theory* (*COLT*), 2023.
- 3. **Spencer Frei\***, Gal Vardi\*, Peter L. Bartlett, and Nathan Srebro. The double-edged sword of implicit bias: Generalization vs. robustness in ReLU networks. *Preprint*, arXiv:2303.01456.
- 4. **Spencer Frei\***, Gal Vardi\*, Peter L. Bartlett, Nathan Srebro, and Wei Hu. Implicit bias in leaky ReLU networks trained on high-dimensional data. *International Conference on Learning Representations (ICLR)*, 2023. (Spotlight)
- 5. **Spencer Frei**, Niladri Chatterji, and Peter L. Bartlett. Random feature amplification: Feature learning and generalization in neural networks. *Journal of Machine Learning Research*, 2023+ (accepted pending minor revision).
- 6. **Spencer Frei**, Niladri Chatterji, and Peter L. Bartlett. Benign overfitting without linearity: Neural network classifiers trained by gradient descent for noisy linear data. *Conference on Learning Theory (COLT)*, 2022.

- 7. **Spencer Frei\***, Difan Zou\*, Zixiang Chen\*, and Quanquan Gu. Self-training converts weak learners to strong learners in mixture models. *International Conference on Artificial Intelligence and Statistics* (AISTATS), 2022.
- 8. **Spencer Frei** and Quanquan Gu. Proxy convexity: A unified framework for the analysis of neural networks trained by gradient descent. *Advances in Neural Information Processing Systems (NeurIPS)*, 2021.
- 9. Difan Zou\*, **Spencer Frei\***, and Quanquan Gu. Provable robustness of adversarial training for learning halfspaces with noise. *International Conference on Machine Learning (ICML)*, 2021.
- 10. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Provable generalization of SGD-trained neural networks of any width in the presence of adversarial label noise. *International Conference on Machine Learning* (*ICML*), 2021.
- 11. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Agnostic learning of halfspaces with gradient descent via soft margins. *International Conference on Machine Learning (ICML)*, 2021. (Long Talk)
- 12. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Agnostic learning of a single neuron with gradient descent. *Advances in Neural Information Processing Systems (NeurIPS)*, 2020.
- 13. Ariana E. Anderson, Mirella Diaz-Santos, **Spencer Frei** *et al.* Hemodynamic latency is associated with reduced intelligence across the lifespan: an fMRI DCM study of aging, cerebrovascular integrity, and cognitive ability. *Brain Structure and Function*, 2020.
- 14. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Algorithm-dependent generalization bounds for overparameterized deep residual networks. *Advances in Neural Information Processing Systems (NeurIPS)*, 2019.
- 15. Spencer Frei and Edwin Perkins. A lower bound for  $p_c$  in range-R bond percolation in two and three dimensions. *Electronic Journal of Probability* 21(56), 2016.
- 16. **Spencer Frei**, Kathryn Lockwood, Greg Stewart, Justin Boyer, and Burt S. Tilley, On thermal resistance in concentric residential geothermal heat exchangers. *Journal of Engineering Mathematics* 86(1), 2014.

\* indicates equal contribution.

#### **INDUSTRY EXPERIENCE**

Applied Scientist Intern, Amazon Alexa AI, Cambridge, MA	Summer 2020
— Worked on natural language understanding using Transformer-based multilingual language	ge models.
<ul> <li>Student Researcher, Chatterbaby/UCLA School of Medicine, Los Angeles, CA</li> <li>— Developed deep learning models for audio analysis of infant cries that were deployed in (100k+ downloads on Android). Employed 20 hr/week when not teaching</li> </ul>	2018–2020 Chatterbaby app
<ul> <li>Freelance Biostatistical Consultant, Ritter Pharmaceuticals, Los Angeles, CA</li> <li>— Consulted on the analysis of clinical trial data using linear regression and mixed effects n</li> </ul>	2017–2019 nodels.
<ul> <li>Student Researcher, Blackthorn Therapeutics/UCLA School of Medicine, Los Angeles, CA</li> <li>— Analyzed MRI and neuropsychiatric data using generalized linear models for a biotech cor project. Employed 20 hr/week when not teaching.</li> </ul>	2016–2018 npany-sponsored
HONORS	
<ul> <li>Rising Star in Machine Learning, University of Maryland, 2022.</li> <li>Best Reviewer Award: ICML 2020, ICML 2021, NeurIPS 2021, ICLR 2022.</li> </ul>	

- Dissertation Year Fellowship, UCLA, 2020–2021.
- Most Promising Computational Statistician, UCLA, 2016.
- Research Fellowship, Montréal Institut des sciences mathématiques, 2012.

# TALKS

<ul> <li>"Benign overfitting from KKT conditions for margin maximization"</li> <li>Conference on Learning Theory, Bangalore</li> </ul>	July 2023
<ul> <li>"Implicit regularization and benign overfitting for neural networks in high dimensions"</li> <li>Youth in High Dimensions Workshop, International Center for Theoretical Physics, Trieste</li> </ul>	May 2023
— UC Berkeley, Department of Biostatistics Seminar	April 2023
— University of British Columbia, Mathematics of Information, Learning, and Data Seminar	January 2023
— University of Alberta, Dept. of Mathematical and Statistical Sciences, Statistics Seminar	October 2022
— EPFL, Fundamentals of Learning and Artificial Intelligence Seminar	September 2022
• "Statistical and computational phenomena in deep learning"	E.L. 2022
- University of Wisconsin-Madison, Department of Statistics Seminar	February 2023
— University of British Columbia, Department of Statistics Seminar	February 2023
— University of Illinois, Urbana-Champaign, Department of Statistics Seminar	February 2023
— University of Michigan, Department of Statistics Seminar	January 2023
— University of British Columbia, Department of Mathematics Colloquium	January 2023
- Northwestern University, Department of Statistics and Data Science Seminar	January 2023
— University of California, Davis, Department of Statistics Seminar	January 2023
— University of California, Davis, Department of Mathematics Colloquium	January 2023
— Boston University, Department of Mathematics and Statistics Seminar	January 2023
— University of California, San Diego, Department of Mathematics Colloquium	December 2022
— University of California, Irvine, Department of Statistics Seminar	December 2022
<ul> <li>"Statistical learning theory, optimization, and neural networks" (two hour tutorial)</li> <li>— Simons Institute, Deep Learning Theory Workshop &amp; Summer School</li> </ul>	August 2022
<ul> <li>"Benign overfitting without linearity"</li> <li>University of Southern California, Symposium on Frontiers of Machine Learning and AL</li> </ul>	November 2022
— Joint Statistical Meetings Washington D C	August 2022
— Conference on Learning Theory London	July 2022
— ETH Zürich Data Algorithms Combinatorics & Optimization Seminar	June 2022
— Harvard University Probabilitas Seminar	May 2022
— University of Toronto, Statistics Research Day	May 2022 May 2022
— University of British Columbia, Christos Thrampoulidis group meeting	April 2022
— Theory of Overparameterized Machine Learning Workshop	April 2022
— Google Research, Algorithms Seminar	March 2022
— Oxford University, Yee Whye Teh group meeting	March 2022
— NSF/Simons Mathematics of Deep Learning Seminar	March 2022
• "Random feature amplification: Feature learning and generalization in neural networks"	
— EPFL, Nicolas Flammarion group meeting	October 2022
— Microsoft Research, Machine Learning Foundations Seminar	April 2022
— Columbia University, Daniel Hsu group meeting	April 2022
— Theory of Overparameterized Machine Learning Workshop	April 2022
• "Self-training converts weak learners to strong learners in mixture models" — Simons Institute for the Theory of Computing Deep Learning Theory Symposium	December 2021
• "Proxy convexity: A unified optimization framework for neural networks trained by gradient	descent"

— Simons Institute for the Theory of Computing, Meet the Fellows Welcome Event September 2021

- "Generalization of SGD-trained neural networks in the presence of adversarial label noise"
- ETH Zürich, Young Data Science Researchers Seminar
- Johns Hopkins University, Machine Learning Seminar
- Max-Planck-Institute MiS, Machine Learning Seminar
- --- NSF/Simons Mathematics of Deep Learning Seminar

# **PROFESSIONAL SERVICE**

• Workshop co-organizer: Deep Learning Theory Workshop & Summer School, Simons Institute for the Theory of Computing, Berkeley, 2022.

- Area Chair for conferences: NeurIPS 2023.
- Reviewer for journals: Annals of Statistics, Journal of Machine Learning Research, SIAM Journal on Mathematics of Data Science, Neural Computation, Mathematics of Operations Research, Transactions on Machine Learning Research.
- Reviewer for conferences: ICML 2020, NeurIPS 2020, AISTATS 2021, ICML 2021, NeurIPS 2021, ICLR 2022, AISTATS 2022, ICML 2022, ICLR 2023, COLT 2023.
- Reviewer for workshops: Theory of Overparameterized Machine Learning (TOPML) 2021, ICML Workshop on Overparameterization: Pitfalls & Opportunities (ICMLOPPO) 2021, TOPML 2022.
- Reviewer, ENVISION Research Competition for Women in STEM, 2022.
- Volunteer for Queer in AI.

# CONFERENCE, WORKSHOP, AND PROGRAM PARTICIPATION

- Conference on Learning Theory. Bangalore, 2023.
- Youth in High Dimensions. Trieste, 2023.
- Joint Statistical Meetings. Washington, DC, 2022.
- Deep Learning Theory Summer Cluster. Simons Institute for the Theory of Computing, Berkeley, 2022.
- Conference on Learning Theory. London, 2022.
- Deep Learning Theory Symposium. Simons Institute for the Theory of Computing, Berkeley, 2021.
- Mathematical/Scientific Foundations of Deep Learning Annual Meeting. Simons Foundation, New York, 2021.
- ICML Workshop on Overparameterization: Pitfalls and Opportunities. Online, 2021.
- Theory of Overparameterized Machine Learning (TOPML) Workshop. Rice University (online), 2021; 2022.
- Theory of Deep Learning Special Quarter. TTIC/Northwestern Institute for Data, Econometrics, Algorithms, and Learning (online) 2020.
- Emerging Challenges in Deep Learning Workshop. Simons Institute, Berkeley, 2019.
- Summer School in Probability. Pacific Institute for the Mathematical Sciences, 2014.

# **TEACHING EXPERIENCE**

- UCLA, Department of Statistics
- TA, Stats 100C: Linear Models, Spring 2020.
- TA, Stats 102C: Monte Carlo Methods, Fall 2019.
- TA, Stats 100B: Mathematical Statistics, Winter 2016.
- TA, Stats 100A: Probability Theory, Fall 2016.
- TA, Stats 10: Intro to Statistics, Summer 2016.

# PROGRAMMING LANGUAGES AND SKILLS

Python, PyTorch, TensorFlow, R, Matlab, AWS (EC2, S3).

April 2021 April 2021 March 2021 February 2021