

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.

ACADEMIC APPOINTMENTS

Assistant Professor, Department of Statistics, UC Davis *Starting Fall 2023*

Postdoctoral Fellow, Simons Institute for the Theory of Computing, UC Berkeley *2021–present*

— Mentors: Peter Bartlett and Bin Yu.

— Part of the [NSF/Simons Collaboration on the Theoretical Foundations of Deep Learning](#).

Visiting Scientist, École polytechnique fédérale de Lausanne (EPFL), Switzerland *Sep. & Oct. 2022*

— Hosted by Emmanuel Abbé.

EDUCATION

Ph.D, Statistics, UCLA *2015–2021*

— Co-advisors: Quanquan Gu and Ying Nian Wu; committee members: Arash Amini and Qing Zhou.

— Thesis: Statistical learning with neural networks trained by gradient descent.

MSc., Mathematics, University of British Columbia, Vancouver *2013–2015*

— Advisor: Edwin A. Perkins.

— Thesis: A lower bound for the critical probability in range- R bond percolation.

BSc., Mathematics, McGill University, Montréal *2009–2013*

— First class honours.

PUBLICATIONS AND PREPRINTS

1. **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. *Preprint*, arXiv:2303.01462.
2. **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.
3. **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**)
4. **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).
5. **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.
6. **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.
7. **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.

8. Difan Zou*, **Spencer Frei***, and Quanquan Gu. Provable robustness of adversarial training for learning halfspaces with noise. *International Conference on Machine Learning (ICML)*, 2021.
9. **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.
10. **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)**
11. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Agnostic learning of a single neuron with gradient descent. *Advances in Neural Information Processing Systems (NeurIPS)*, 2020.
12. 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.
13. **Spencer Frei**, Yuan Cao, and Quanquan Gu. Algorithm-dependent generalization bounds for overparameterized deep residual networks. *Advances in Neural Information Processing Systems (NeurIPS)*, 2019.
14. **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.
15. **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

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| Applied Scientist Intern, Amazon Alexa AI, Cambridge, MA | <i>Summer 2020</i> |
| — Worked on natural language understanding using Transformer-based multilingual language models. | |
| Student Researcher, Chatterbaby/UCLA School of Medicine, Los Angeles, CA | <i>2018–2020</i> |
| — Developed deep learning models for audio analysis of infant cries that were deployed in Chatterbaby app (100k+ downloads on Android). Employed 20 hr/week when not teaching. | |
| Freelance Biostatistical Consultant, Ritter Pharmaceuticals, Los Angeles, CA | <i>2017–2019</i> |
| — Consulted on the analysis of clinical trial data using linear regression and mixed effects models. | |
| Student Researcher, Blackthorn Therapeutics/UCLA School of Medicine, Los Angeles, CA | <i>2016–2018</i> |
| — Analyzed MRI and neuropsychiatric data using generalized linear models for a biotech company-sponsored project. Employed 20 hr/week when not teaching. | |

HONORS

- Rising Star in Machine Learning, University of Maryland, 2022.
- Best Reviewer Award: ICML 2020, ICML 2021, NeurIPS 2021, ICLR 2022.
- Dissertation Year Fellowship, UCLA, 2020–2021.
- Most Promising Computational Statistician, UCLA, 2016.
- Research Fellowship, Montréal Institut des sciences mathématiques, 2012.

TALKS

- “Statistical and computational phenomena in deep learning”
 - 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*
- “Implicit regularization and benign overfitting for neural networks in high dimensions”
 - 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 learning theory, optimization, and neural networks” (two hour tutorial)
 - Simons Institute, Deep Learning Theory Workshop & Summer School *August 2022*
- “Benign overfitting without linearity”
 - University of Southern California, Symposium on Frontiers of Machine Learning and AI *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, Probabilistic Seminar *May 2022*
 - University of Toronto, Statistics Research Day *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 *April 2021*
 - Johns Hopkins University, Machine Learning Seminar *April 2021*
 - Max-Planck-Institute MiS, Machine Learning Seminar *March 2021*
 - NSF/Simons Mathematics of Deep Learning Seminar *February 2021*

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*, *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

- 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, TensorFlow, R, Matlab, AWS (EC2, S3).