SPENCER FREI

Research Scientist, Google DeepMind ◇ spencerfrei.github.io ◇ sfrei@google.com ◇ Google Scholar

EMPLOYMENT

Senior Research Scientist, Google DeepMind *2025–present*

Assistant Professor, Department of Statistics, University of California, Davis *2023–2024*
— Member of the Graduate Group in Computer Science
— Long-term participant at the Simons Institute Fall 2024 program on Modern Paradigms in Generalization

Postdoctoral Fellow, Simons Institute for the Theory of Computing, UC Berkeley *2021–2023*
— Mentors: Peter Bartlett and Bin Yu.
— Visitor at École polytechnique fédérale de Lausanne (EPFL), Sep. & Oct. 2022, hosted by Emmanuel Abbé.

EDUCATION

Ph.D, Statistics, UCLA *2015–2021*
— Co-advisors: Quanquan Gu and Ying Nian Wu.

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

BSc., Mathematics, McGill University, Montréal. *2009–2013*
— First class honours.

PUBLICATIONS AND PREPRINTS (see also Google Scholar)

1. Alexander Tsigler, Luiz F. O. Chamon, **S. Frei**, Peter L. Bartlett. Benign overfitting and the geometry of the ridge regression solution in binary classification. Preprint, arXiv:2503.07966.
2. Usman Anwar, Johannes von Oswald, Louis Kirsch, David Krueger, **S. Frei**. Adversarial robustness of in-context learning in transformers for linear regression. Preprint, arXiv:2411.05189.
3. Shuning Shang, Roey Magan, Zhiwei Xu, **S. Frei**, Gal Vardi, Wei Hu. Benign overfitting in single-head attention. Preprint, arXiv:2410.07746.
4. **S. Frei** and Gal Vardi. Trained transformer classifiers generalize and exhibit benign overfitting in-context. *ICLR 2025*.
5. Nikhil Ghosh, **S. Frei**, Wooseok Ha, Bin Yu. The effect of SGD batch size on autoencoder learning: Sparsity, sharpness and feature learning. *JMLR 2025*.
6. Neil Mallinar*, Austin Zane*, **S. Frei**, Bin Yu. Minimum-norm interpolation under covariate shift. *ICML 2024*.
7. Ruiqi Zhang, **S. Frei**, Peter L. Bartlett. Trained transformers learn linear models in-context. *JMLR 2024*.
8. Zhiwei Xu, Yutong Wang, **S. Frei**, Gal Vardi, Wei Hu. Benign overfitting and grokking in ReLU networks for XOR cluster data. *ICLR 2024*.
9. **S. Frei***, Gal Vardi*, Peter L. Bartlett, Nati Srebro. The double-edged sword of implicit bias: Generalization vs. robustness in ReLU networks. *NeurIPS 2023*.
10. **S. Frei***, Gal Vardi*, Peter L. Bartlett, Nathan Srebro. Benign overfitting in linear classifiers and leaky ReLU networks from KKT conditions for margin maximization. *COLT 2023*.
11. **S. Frei***, Gal Vardi*, Peter L. Bartlett, Nati Srebro, Wei Hu. Implicit bias in leaky ReLU networks trained on high-dimensional data. *ICLR 2023* (**Spotlight**).

12. **S. Frei**, Niladri Chatterji, Peter L. Bartlett. Random feature amplification: Feature learning and generalization in neural networks. *JMLR 2023.*

13. **S. Frei**, Niladri Chatterji, Peter L. Bartlett. Benign overfitting without linearity: Neural network classifiers trained by gradient descent for noisy linear data. *COLT 2022.*

14. **S. Frei***, Difan Zou*, Zixiang Chen*, Quanquan Gu. Self-training converts weak learners to strong learners in mixture models. *AISTATS 2022*.

15. **S. Frei** and Quanquan Gu. Proxy convexity: A unified framework for the analysis of neural networks trained by gradient descent. *NeurIPS 2021.*

16. Difan Zou*, **S. Frei***, Quanquan Gu. Provable robustness of adversarial training for learning halfspaces with noise. *ICML 2021*.

17. **S. Frei**, Yuan Cao, Quanquan Gu. Provable generalization of SGD-trained neural networks of any width in the presence of adversarial label noise. *ICML 2021.*

18. **S. Frei**, Yuan Cao, Quanquan Gu. Agnostic learning of halfspaces with gradient descent via soft margins. *ICML 2021* **(Long Talk)**.

19. Ariana E. Anderson, Mirella Diaz-Santos, **S. 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.

20. **S. Frei**, Yuan Cao, Quanquan Gu. Algorithm-dependent generalization bounds for overparameterized deep residual networks. *NeurIPS 2019*.

21. **S. 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.

22. **S. Frei**, Kathryn Lockwood, Greg Stewart, Justin Boyer, Burt S. Tilley, On thermal resistance in concentric residential geothermal heat exchangers. *Journal of Engineering Mathematics* 86(1), 2014.

* indicates equal contribution.

PRIOR INDUSTRY RESEARCH EXPERIENCE

Applied Scientist Intern, Amazon Alexa AI, Cambridge, MA *Summer 2020*

— Worked on natural language understanding using Transformer-based multilingual language models.

Student Researcher, Chatterbaby/UCLA School of Medicine, Los Angeles, CA *2018–2020*

— 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.

Biostatistical Consultant, Ritter Pharmaceuticals, Los Angeles, CA *2017–2019*

— 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 *2016–2018*

— Analyzed MRI and neuropsychiatric data using generalized linear models for a biotech company-sponsored project. Employed 20 hr/week when not teaching.

HONORS

- Selected for NeurIPS 2023 Tutorial, "Reconsidering Overfitting in the Age of Overparameterized Models"
- 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 $^{\vee}$ **indicates virtual presentation**

• "Generalization and Benign Overfitting In-Context in Trained Transformer Classifiers"
— Columbia University, Statistics Seminar *April 2025*

• "Reconsidering Overfitting in the Age of Overparameterized Models" (three hour tutorial)
— NeurIPS 2023 Tutorial, presented with Vidya Muthukumar and Fanny Yang *December 2023*

• "Learning Linear Models In-Context with Transformers"
— University of Southern California, Department of Data Sciences and Operations Seminar *October 2024*
— UCLA, Department of Statistics and Data Science Seminar *May 2024*
— École normale supérieure, INRIA SIERRA Seminar *April 2024*
— Sorbonne Université and Paris Diderot University, Statistics Seminar *April 2024*
— Apple Machine Learning Research, Cupertino *November 2023*
— University of Basel, Department of Mathematics and Computer Science Seminar *November 2023*
— University of Oxford, Computational Statistics and Machine Learning Seminar *October 2023*
— University of Cambridge, Machine Learning Group *October 2023*
— Google DeepMind, London *October 2023*
— Imperial College London, Imperial + AI Seminar *October 2023*
— The Alan Turing Institute, London, Rough Paths Interest Group$^{\vee}$ *October 2023*
— Stanford University, Tengyu Ma group meeting *September 2023*
— Google Research, In-Context Learning Reading Group$^{\vee}$ *August 2023*

• "Benign Overfitting from KKT Conditions for Margin Maximization"
— Conference on Learning Theory, Bangalore *July 2023*

• "Implicit Regularization and Benign Overfitting for Neural Networks in High Dimensions"
— Youth in High Dimensions Workshop, International Center for Theoretical Physics, Trieste *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"
— University of Wisconsin–Madison, Department of Statistics Seminar$^{\vee}$ *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$^{\vee}$ *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*

• "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, Probabilitas Seminar$^{\vee}$ *May 2022*
— University of Toronto, Statistics Research Day$^{\vee}$ *May 2022*
— University of British Columbia, Christos Thrampoulidis group meeting$^{\vee}$ *April 2022*
— Theory of Overparameterized Machine Learning Workshop$^{\vee}$ *April 2022*
— Google Research, Algorithms Seminar$^{\vee}$ *March 2022*
— Oxford University, Yee Whye Teh group meeting$^{\vee}$ *March 2022*
— NSF/Simons Mathematics of Deep Learning Seminar$^{\vee}$ *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$^{\vee}$ *April 2022*
— Columbia University, Daniel Hsu group meeting$^{\vee}$ *April 2022*
— Theory of Overparameterized Machine Learning Workshop$^{\vee}$ *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$^{\vee}$ *April 2021*
— Johns Hopkins University, Machine Learning Seminar$^{\vee}$ *April 2021*
— Max-Planck-Institute MiS, Machine Learning Seminar$^{\vee}$ *March 2021*
— NSF/Simons Mathematics of Deep Learning Seminar$^{\vee}$ *February 2021*

PROFESSIONAL SERVICE

• Workshop co-organizer: Deep Learning Theory Workshop & Summer School, Simons Institute for the Theory of Computing, Berkeley, 2022.
• Area Chair/Senior PC for conferences: NeurIPS 2023, ALT 2024, NeurIPS 2024, ALT 2025, ICML 2025, NeurIPS 2025.
• Area Chair for workshops: Theoretical Foundations of Foundation Models @ ICML 2024.
• Reviewer for journals: *Annals of Statistics*, *Journal of Machine Learning Research*, *Bernoulli*, *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, ICLR 2025.
• Reviewer for workshops: Theory of Overparameterized Machine Learning (TOPML) 2021, ICML Workshop on Overparameterization: Pitfalls & Opportunities (ICMLOPPO) 2021, TOPML 2022, NeurIPS Workshop on Mathematics of Modern Machine Learning (M3L) 2023, NeurIPS Workshop on Robustness of Few-Shot Learning in Foundation Models (R0-FoMo) 2023.
• Reviewer, ENVISION Research Competition for Women in STEM, 2022.
• Volunteer for Queer in AI.

CONFERENCE, WORKSHOP, AND PROGRAM PARTICIPATION

• Modern Paradigms in Generalization Program (Long-term Participant), Simons Institute, Berkeley, 2024.
• International Conference on Learning Representations. Vienna, 2024.
• Neural Information Processing Systems. New Orleans, 2023.
• 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.
• Neural Information Processing Systems. Vancouver, BC, 2019.
• Emerging Challenges in Deep Learning Workshop. Simons Institute, Berkeley, 2019.
• Summer School in Probability. Pacific Institute for the Mathematical Sciences, Vancouver, BC, 2014.

TEACHING EXPERIENCE

• UC Davis, Department of Statistics
— Instructor, Stats 35B: Statistical Data Science II, Winter 2024.
— Instructor, Stats 250: Theoretical Foundations of Modern AI, Winter 2024.
— Organizer, Stats 290: Seminar in Statistics. Winter 2024.

• 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 with GPUs, JAX with TPUs, R, Matlab.