

Zachary Charles

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Research Interests: Distributed optimization, machine learning, federated learning, robustness, fairness, reproducibility, high-dimensional statistics

Education

University of Wisconsin-Madison — Ph.D in Applied Mathematics (2013 - 2018)

Dissertation: Algebraic and geometric structure in machine learning and optimization algorithms

- Awarded the department's prize for an outstanding dissertation in applied mathematics.

University of Pennsylvania — M.A. in Mathematics (2011 - 2013)

Thesis: Nonstandard analysis and the principle of transfer, and applications to Ramsey theory

University of Pennsylvania — B.A. in Mathematics, and Mathematical Logic (2009 - 2013)

Employment

Google — AI Resident (2019 - Present)

- Developed and implemented novel algorithms for federated learning.
 - Dramatically improved accuracy and reduced training times for multiple first-party customers.
- Created a framework for understanding the impact of algorithmic choices on training speed and quality in federated learning.
 - This framework enabled my team to give concrete, practical algorithm recommendations to customers based on their needs and constraints.
- Actively contributed to Google's open-source [TensorFlow Federated](#) and [Federated Research](#) repositories.
- Authored four publications (lead author on three) at the intersection of optimization, federated learning, and meta-learning.

University of Wisconsin-Madison — Postdoctoral Researcher (2018 - 2019)

- Worked on problems related to distributed optimization, machine learning, and high-dimensional statistics.
- Developed practical and rigorously justified methods for large-scale machine learning.
- Regularly published at top-tier machine learning conferences, including ICML, NeurIPS, and AISTATS.

Center for Communications Research, Princeton — Adjunct Researcher (2014)

National Security Agency — Director's Summer Program (Summer 2012, Summer 2013)

- Worked on applied mathematics problems of national security interest.

College of William and Mary — NSF Funded Researcher (Summer 2011)

- Performed research on matrix analysis, combining theoretical and computational tools, leading to three separate publications.
- Used high-performance computing systems to explore ideas at scale.

Selected Papers

1. S. Reddi*, **Z. Charles***, M. Zaheer, Z. Garrett, K. Rush, J. Konečný, S. Kumar, H. B. McMahan. [Adaptive Federated Optimization](#). (in submission, * denotes equal contributions)
2. **Z. Charles**, J. Konečný. [On the Outsized Importance of Learning Rates in Local Update Methods](#). (in submission)
3. **Z. Charles**, J. Konečný. Convergence and Accuracy Trade-offs in Federated and Meta-Learning. (in submission)
4. P. Kairouz, H. B. McMahan, ... (over fifty contributors including **Z. Charles**) [Advances and Open Problems in Federated Learning](#). (in submission)
5. S. Rajput, H. Wang, **Z. Charles**, D. Papailiopoulos. [DETOX: A Redundancy-Based Framework for Faster and More Robust Gradient Aggregation](#). NeurIPS 2019.
6. **Z. Charles**, H. Rosenberg, D. Papailiopoulos. [A Geometric Perspective on the Transferability of Adversarial Directions](#). AISTATS, 2019.
7. S. Rajput, Z. Feng, **Z. Charles**, P. Loh, D. Papailiopoulos. [Does Data Augmentation Lead to Positive Margin?](#) ICML, 2019.
8. H. Wang, S. Sievert, **Z. Charles**, S. Liu, S. Wright, D. Papailiopoulos. [ATOMO: Communication-efficient Learning via Atomic Sparsification](#). NeurIPS, 2018.
9. **Z. Charles** and D. Papailiopoulos. [Stability and Generalization of Learning Algorithms that Converge to Global Optima](#). ICML, 2018.

Selected Talks

1. **Adaptive Federated Optimization**. *OpenMinedPrivacy Conference*, August 2020. [\[recording\]](#)
2. **Building Your Own Federated Learning Algorithm in TensorFlow Federated**. *Workshop on Federated Learning and Analytics*, July 2020. [\[recording\]](#)
3. **On the Outsized Importance of Learning Rates in FL**. *Federated Learning One World (FLOW) Seminar*, July 2020. [\[recording\]](#)
4. **DETOX: A Redundancy Framework for Robust Gradient Aggregation**. *INFORMS Annual Meeting*, November 2019.
5. **ATOMO: Communication-efficient Learning via Atomic Sparsification**. *INFORMS Annual Meeting*, November 2018.
6. **Stability and generalization of convergent learning algorithms under the Lojasiewicz inequality**. *AMS Session on Algebra, Machine Learning, and Data Privacy*, October 2018.
7. **Stability and Generalization of Learning Algorithms that Converge to Global Optima**. *International Conference on Machine Learning*, June 2018.

Teaching Experience

Teaching Assistant:

- Calculus II, University of Wisconsin-Madison, Spring 2015.
- Calculus I, University of Wisconsin-Madison, Fall 2014.
- Calculus II, University of Wisconsin-Madison, Spring 2014.
- Calculus I, University of Wisconsin-Madison, Fall 2013.
- Linear Algebra and Differential Equations, University of Pennsylvania, Spring 2013.
- Introduction to Real Analysis, University of Pennsylvania, Fall 2012.
- Introduction to Logic, University of Pennsylvania, Spring 2012.

Volunteer Work

- **Technical Program Volunteer**, [Technology Access Foundation](#), Seattle WA.
 - Taught elementary and middle school students in the Seattle public school system the basics of HTML, CSS, and web development.
- **Mathematics and Science Tutor**, Centro Hispano, Madison WI.
 - Provided academic support to Latinx students in the Dane county public school system as part of the [Escalera](#) program.
- **Discovery Science Volunteer**, Wisconsin Institute for Discovery, Madison WI.
 - Led interactive science exhibits designed to encourage kids and families to explore scientific topics, as part of the monthly [Saturday Science](#) program
- **Schools of Hope Volunteer**, Akira Toki Middle School, Madison, WI.
 - Provided one-on-one academic support to students as part of the [Schools of Hope](#) program.