

Zachary Charles

Postdoctoral Researcher

University of Wisconsin-Madison

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Education

- 2013–2018 **PhD in Applied Mathematics**, *University of Wisconsin-Madison*.
Supervisor: Nigel Boston
Dissertation: Algebraic and geometric structure in machine learning and optimization algorithms
Minor: Computer Science
- 2009–2013 **B.A. and M.A. in Mathematics**, *University of Pennsylvania*.

Research Interests

Broad interests: Machine learning, optimization, distributed algorithms, communication-efficient distributed methods, computational mathematics

Specific interests: I work at the intersection of machine learning and optimization. I focus on geometric and statistical properties of optimization methods for machine learning, as well as designing efficient distributed algorithms. I am also interested in adversarial attacks, as well as the role of overparameterization in neural networks.

Research Experience

- 2016 **Machine Learning Intern**, *MIT Lincoln Laboratory*, Lexington, MA.
Developed, implemented, and evaluated machine learning methods for mission-driven applications. Combined natural language processing with semi-supervised learning to improve operational algorithms.
- 2014 **Adjunct Researcher**, *Center for Communications Research*, Princeton, NJ.
Worked on national security problems related to cryptography, signal processing, and computational mathematics. Analyzed the role of modern optimization methods in these areas and implemented combinatorial optimization methods for cryptanalysis.
- 2012 – 2013 **Director's Summer Program**, *National Security Agency*, Fort Meade, MD.
Created algorithms to solve cryptographic problems related to national security. Developed mathematical theory to help advance the study of these problems within the agency. Served as a visiting researcher to the Heilbronn Institute for Mathematical Research.

Publications

Machine Learning and Optimization

Hongyi Wang, Scott Sievert, Shengchao Liu, Zachary Charles, Dimitris Papailiopoulos, Stephen Wright. *ATOMO: Communication-efficient Learning via Atomic Sparsification*. NIPS, 2018.

Zachary Charles, Dimitris Papailiopoulos. *Stability and Generalization of Learning Algorithms that Converge to Global Optima*. ICML, 2018.

Lingjiao Chen, Hongyi Wang, Zachary Charles, Dimitris Papailiopoulos. *DRACO: Robust Distributed Training via Redundant Gradients*. ICML, 2018.

Zachary Charles, Dimitris Papailiopoulos. *Gradient Coding Using the Stochastic Block Model*. ISIT, 2018.

Zachary Charles, Amin Jalali, Rebecca Willett. *Subspace Clustering with Missing and Corrupted Data*. IEEE Data Science Workshop, 2018.

In Submission:

Zachary Charles, Harrison Rosenberg, Dimitris Papailiopoulos. *A Geometric Perspective on the Transferability of Adversarial Directions*.

Hongyi Wang, Zachary Charles, Dimitris Papailiopoulos. *EraseHead: Distributed Gradient Descent Without Delays Using Approximate Gradient Codes*.

Zachary Charles, Dimitris Papailiopoulos, Jordan Ellenberg. *Approximate Gradient Coding via Sparse Random Graphs*.

Applied and Computational Mathematics

Zachary Charles, Nigel Boston. *Exploiting Algebraic Structure in Global Optimization and the Belgian Chocolate Problem*. Journal of Global Optimization, 2018.

Zachary Charles. *Generating Random Factored Ideals in Number Fields*. Mathematics of Computation, 2018.

Alisha Zachariah, Zachary Charles, Nigel Boston, Bernard Lesieutre. *Distributions of the Number of Solutions to the Network Power Flow Equations*. ISCAS, 2018.

Alisha Zachariah, Zachary Charles. *Efficiently Finding All Power Flow Solutions to Tree Networks*. Allerton, 2017.

Zachary Charles, Miriam Farber, Charles R Johnson, Lee Kennedy-Shaffer. *Nonpositive Eigenvalues of Hollow, Symmetric, Nonnegative Matrices*. SIAM Journal on Matrix Analysis and Applications, 2013.

Zachary Charles, Miriam Farber, Charles R Johnson, Lee Kennedy-Shaffer. *Nonpositive Eigenvalues of the Adjacency Matrix and Lower Bounds for Laplacian Eigenvalues*. Discrete Mathematics, 2013.

Zachary Charles, Miriam Farber, Charles R Johnson, Lee Kennedy-Shaffer. *The Relation Between the Diagonal Entries and the Eigenvalues of a Symmetric Matrix, Based upon the Sign Pattern of its Off-Diagonal Entries*. Linear Algebra and its Applications, 2013.

Awards

2017 **John Nohel Prize in Applied Mathematics**, Department of Mathematics, University of Wisconsin-Madison

2015–2017 **NSF Graduate Research Fellowship**, Department of Mathematics, University of Wisconsin-Madison

2015 **Graduate Student Teaching Award**, Department of Mathematics, University of Wisconsin-Madison

2012 **Richard Garfield Award for Combinatorics**, Department of Mathematics, University of Pennsylvania

2009–2013 **Dean's Scholar Award**, University of Pennsylvania

Recent and Upcoming Talks

Nov 2018 **ATOMO: Communication-efficient learning via atomic sparsification**.
INFORMS Annual Meeting, Phoenix, AZ

- Oct 2018 **Stability and generalization of convergent learning algorithms under the Lojasiewicz inequality.**
AMS Session on Algebra, Machine Learning, and Data Privacy, Ann Arbor, MI
- Sept 2018 **Optimization and geometric properties of linear neural networks.**
Mathematics of Neural Networks Workshop, Boston College
- July 2018 **Stability and generalization of learning algorithms that converge to global optima.**
ICML, Stockholm, Sweden
- June 2018 **Gradient coding using the stochastic block model.**
ISIT, Vail, CO
- June 2018 **Subspace clustering with missing and corrupted data.**
IEEE Data Science Workshop, Lausanne, Switzerland
- June 2018 **Stability and generalization of convergent learning algorithms.**
Center for Communications Research Colloquium, Princeton, NJ
- Apr 2018 **Stability and generalization of convergent learning algorithms.**
Institute for the Foundations of Data Science Student Workshop, University of Wisconsin-Madison
- Jul 2018 **Adversarial examples in machine learning.**
Systems, Information, Learning, and Optimization (SILO) Seminar, University of Wisconsin-Madison
- Jul 2017 **One weird trick to improve concentration of graphs.**
Systems, Information, Learning, and Optimization (SILO) Seminar, University of Wisconsin-Madison
- Apr 2017 **Algebraic approaches to the Belgian chocolate problem.**
Applied Algebra Seminar, University of California-Berkeley

Teaching Experience

- 2013 – 2015 **University of Wisconsin-Madison, Teaching Assistant.**
Led discussion sections, wrote and graded quizzes, held office hours, and led extended review sessions. Consistently received excellent TA evaluations and was awarded for my teaching ability.
 - Spring 2015: Calculus II
 - Fall 2014: Calculus I
 - Spring 2014: Calculus II
 - Fall 2013: Calculus I
- 2012 – 2013 **University of Pennsylvania, Teaching Assistant.**
Led discussion sections, and graded quizzes/exams. Consistently received excellent TA evaluations.
 - Spring 2013: Linear Algebra and Differential Equations
 - Fall 2012: Introduction to Real Analysis
 - Spring 2012: Introduction to Logic

Volunteer Work

- 2018 **Madison East High School, Centro Hispano Volunteer, Madison, WI.**
Served as a volunteer for Centro Hispano. Tutored students in mathematics and helped with resume building, focusing on minority students and students struggling academically, as part of the Escalera program of Centro Hispano.
- 2016 – 2017 **Wisconsin Institute for Discovery, Discovery Volunteer, Madison, WI.**
Led science-based activities as part of Science Saturdays. Taught children and adults about various scientific concepts using interactive and fun games, demonstrations, and experiments.
- 2016 **Akira Toki Middle School, Schools of Hope Volunteer, Madison, WI.**
Served as a volunteer for Schools of Hope. Tutored students in mathematics, focusing one-on-one with students struggling academically and differently abled students.