

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

- 2018 – **Postdoctoral Researcher**, *University of Wisconsin-Madison*, Madison, WI.
- Present I work as a postdoctoral researcher with Professor Dimitris Papailiopoulos. My research involves developing and understanding algorithms for machine learning.
- 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

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

○ Awarded to graduate students with outstanding dissertations in applied mathematics.

2015–2017 **NSF Thesis Launch Research Award**, Department of Mathematics, University of Wisconsin-Madison

○ Awarded multiple semesters of funding for promising research as a graduate student.

Fall 2014 **Graduate Student Teaching Award**, Department of Mathematics, University of Wisconsin-Madison

○ Awarded to graduate students with exemplary teaching evaluations.

- 2012 **Richard Garfield Award for Combinatorics**, Department of Mathematics, University of Pennsylvania
- Awarded to undergraduate students with promising research on combinatorics.

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.