Erin Claire Carson

Curriculum Vitae

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Education

2009-2015 Ph.D. in Computer Science, with a Designated Emphasis in Computational and Data Science and Engineering, University of California Berkeley.

2005-2009 B.S. in Computer Science, with Minors in Applied Mathematics and Materials Science, University of Virginia.

PhD Thesis

Title *Communication-avoiding Krylov Subspace Methods in Theory and Practice*

Supervisors Professor James Demmel & Professor Armando Fox

Description This thesis evaluates tradeoffs between performance and accuracy in communication-avoiding Krylov subspace solvers for high-performance scientific codes.

Professional Appointments

2019 PRIMUS Research Fellow, Department of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University.

2018–2019 Vědecký Pracovník, Department of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University.

2015–2018 Courant Instructor/Assistant Professor, Courant Institute of Mathematical Sciences, New York University.

Grants

2019 Primary Investigator of the PRIMUS Research Program "Scalable and Accurate Numerical Linear Algebra for Next-Generation Hardware *(until September 2022)*, Charles University.

Publications

Journal Papers

2019 E. Carson and Z. Strakoš, *On the Cost of Iterative Computations*, Royal Society Philosophical Transactions A (to appear).

2019 E. Carson, *An Adaptive s-step Conjugate Gradient Algorithm with Dynamic Basis Updating*, Applications of Mathematics (to appear).

2018 E. Carson, M. Rozložník, Z. Strakoš, P. Tichý, and M. Tůma, *The Numerical Stability Analysis of Pipelined Conjugate Gradient Methods: Historical Context and Methodology*, SIAM Journal on Scientific Computing, 40(5), 2018, pp. A3549-3580.

2018 E. Carson, *The Adaptive s-step Conjugate Gradient Method*, SIAM Journal on Matrix Analysis and Applications, 39(3), 2018, pp. 1318-1338.

2018 E. Carson and N. Higham, *Accelerating the Solution of Linear Systems by Iterative Refinement in Three Precisions*, SIAM Journal on Scientific Computing, 40(2), 2018, pp. A817-A847 .

2017 E. Carson and N. Higham, *A New Analysis of Iterative Refinement and its Application to Accurate Solution of Ill-Conditioned Sparse Linear Systems*, SIAM Journal on Scientific Computing, 39(6), 2017, pp. A2834-A2856.

2016 E. Solomonik, E. Carson, N. Knight, and J. Demmel, *Tradeoffs between Synchronization, Communication, and Computation in Parallel Linear Algebra Computations*, ACM Transactions on Parallel Computing (TOPC), 3(1), 2016, pp. 3:1-3:47.

2015 E. Carson and J. Demmel, *Accuracy of the s-Step Lanczos Method for the Symmetric Eigenproblem in Finite Precision*, SIAM Journal on Matrix Analysis and Applications, 36(2), 2015, pp. 793-819.

2014 E. Carson, N. Knight, and J. Demmel, *An Efficient Deflation Technique for the Communication-Avoiding Conjugate Gradient Method*, Electronic Transactions on Numerical Analysis, 43, 2014, pp. 125-141.

2014 G. Ballard, E. Carson, J. Demmel, M. Hoemmen, N. Knight, and O.Schwartz, *Communication Lower Bounds and Optimal Algorithms for Numerical Linear Algebra*, Acta Numerica, 23, 2014, pp. 1-155.

2014 N. Knight, E. Carson and J. Demmel, *Exploiting Data Sparsity in Parallel Matrix Powers Computations*, in Parallel Processing and Applied Mathematics, R. Wyrzykowski, J. Dongarra, K. Karczewski, and J. Waniewski, eds., Lecture Notes in Computer Science, Springer Berlin Heidelberg, 2014, pp. 15-25.

2014 E. Carson and J. Demmel, *A Residual Replacement Strategy for Improving the Maximum Attainable Accuracy of s-Step Krylov Subspace Methods*, SIAM Journal on Matrix Analysis and Applications, 35(1), 2014, pp. 22-43.

2013 E. Carson, N. Knight, and J. Demmel, *Avoiding Communication in Nonsymmetric Lanczos-based Krylov Subspace Methods*, SIAM Journal on Scientific Computing, 35(5), 2013, pp. S42-S61.

Conference Proceedings

2016 Carson, E., Demmel, J., Grigori, L., Knight, N., Koanantakool, P., Schwartz, O. and Simhadri, H.V., *Write-Avoiding Algorithms*, in Proceedings of the 30th IEEE International Parallel and Distributed Processing Symposium, 2016, pp.648-658.

2014 E. Solomonik, E. Carson, N. Knight, and J. Demmel, *Tradeoffs Between Synchronization, Communication, and Work in Parallel Linear Algebra Computations*, in Proceedings of the 26th ACM Symposium on Parallelism in Algorithms and Architectures (SPAA), 2014.

2014 S. Williams, E. Carson, M. Lijewski, N. Knight, A. Almgren, B. Van Straalen, and J. Demmel, *s-Step Krylov Subspace Methods as Bottom Solvers for Geometric Multigrid*, in Proceedings of the 28th IEEE International Parallel and Distributed Processing Symposium, 2014.

2007 J. Carnahan, S. Policastro, E. Carson, P. Reynolds Jr., and R. Kelly, *Using Flexible Points in a Developing Simulation of Selective Dissolution in Alloys*, in Proceedings of the 39th Winter Simulation Conference, IEEE Press, 2007, pp.891-899.

Presentations

2019 **Panelist:** "The Road to Exascale and Beyond Is Paved by Software: How Algorithms, Libraries and Tools Will Make Exascale Performance Real", Supercomputing 2019, November 17-22, 2019 (to appear).

2019 **Invited Talk:** "The Cost of Iterative Computations", Advanced Solvers for Modern Architectures, Muenster, Germany, November 11-13, 2019 (to appear).

2019 **Invited Keynote Talk:** "Iterative Refinement in Three Precisions", PACO 2019: 3rd Workshop on Power-Aware Computing, Magdeburg, Germany, November 5-6, 2019 (to appear).

2019 "Iterative Refinement in Three Precisions", Parallel Solution Methods for Systems Arising from PDEs, Centre International De Rencontres MathÃIматiques (CIRM), Luminy, France, September 16-20, 2019.

2019 "On the Amplification of Rounding Errors", Advances in Numerical Linear Algebra: Celebrating the Centenary of the Birth of James H. Wilkinson, Manchester, UK, May 29-30, 2019.

2019 **Invited Keynote Talk:** "The Cost of Iterative Computations", High-Performance Computing in Science and Engineering (HPCSE19), Soláň, Czech Republic, May 20-23, 2019.

2019 **Invited Talk:** "Iterative Linear Algebra in the Exascale Era", Numerical Algorithms for High-Performance Computational Science, The Royal Society, London, UK, April 8-9, 2019.

2019 "The s-step Conjugate Gradient Method in Finite Precision", SIAM Computational Science and Engineering (CSE19), Spokane, Washington, February 25 - March 1, 2019.

2019 **Invited Lectures:** "High Performance Variants of Krylov Subspace Methods, Parts I and II", Seminar on Numerical Analysis and Winter School, Ostrava, Czech Republic, January 21-25, 2019.

2018 "Exploiting Multiprecision Hardware in Solving Linear Systems and Least Squares Problems", Current Problems in Numerical Analysis Seminar, Institute of Mathematics, Czech Academy of Sciences, Prague, Czech Republic, December 14, 2018.

2018 "Sparse Matrix Computations in the Exascale Era", Seminar of Numerical Mathematics, Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic, November 15, 2018.

2018 "Error Bounds for Iterative Refinement in Three Precisions", SIAM Annual Meeting (AN18), Portland, Oregon, July 13, 2018.

2018 "High Performance Variants of Krylov Subspace Methods", SIAM Parallel Processing (PP18), Tokyo, Japan, March 8, 2018.

2017 "Preconditioned GMRES-based Iterative Refinement for the Solution of Sparse, Ill-Conditioned Linear Systems", International Conference on Preconditioning Techniques for Scientific and Industrial Applications (Preconditioning 17), Vancouver, Canada, August 2, 2017.

2017 **Invited Seminar Talk:** "Communication-Avoiding Algorithms: Challenges and New Results", Numerical Analysis and Scientific Computing Seminar, University of Manchester, UK, July 19, 2017.

2017 "Communication-Avoiding Algorithms: Challenges and New Results", SIAM Annual Meeting (AN17), Pittsburgh, Pennsylvania, July 13, 2017.

2017 **Invited Plenary Lecture:** "The Behavior of Synchronization-Reducing Variants of the Conjugate Gradient Method in Finite Precision", Householder Symposium XX, Blacksburg, Virginia, June 19, 2017.

2017 **Invited Plenary Lecture:** "High-Performance Krylov Subspace Method Variants and their Behavior in Finite Precision", High Performance Computing in Science and Engineering (HPCSE17), Soláň, Czech Republic, May 24, 2017.

2017 **Invited Seminar Talk:** "High-Performance Krylov Subspace Method Variants and their Behavior in Finite Precision", MORE Seminar, Charles University, Prague, Czech Republic, May 15, 2017.

2016 **Invited Seminar Talk:** "Performance and Stability Tradeoffs in Large-Scale Krylov Subspace Methods", Applied Mathematics and Scientific Computing Seminar, Temple University, November 16, 2016.

2016 "Communication-Avoiding Krylov Subspace Methods in Theory and Practice", SIAM Conference on Parallel Processing, Paris, France, April 12-15, 2016.

2015 "The s-Step Lanczos Method and its Behavior in Finite Precision", SIAM Conference on Applied Linear Algebra, Atlanta, Georgia, October 26-30, 2015.

2015 "Communication-Avoiding Krylov Methods in Theory and Practice", DMML Workshop, Berkeley, CA, October 23-24, 2015.

2015 "Efficient Deflation-Based Preconditioning for the Communication-Avoiding Conjugate Gradient Method", SIAM Conference on Computational Science and Engineering, Salt Lake City, Utah, March 14-18, 2015.

2014 **Invited Seminar Talk:** "Communication-Avoiding Krylov Subspace Methods in Finite Precision", Linear Algebra and Optimization Seminar, ICME, Stanford University, December 4, 2014.

2014 "Avoiding Communication in Bottom Solvers for Geometric Multigrid Methods", 8th International Workshop on Parallel Matrix Algorithms and Applications, Lugano, Switzerland, July 2-4, 2014.

2014 "Improving the Maximum Attainable Accuracy of Communication-Avoiding Krylov Subspace Methods", Householder Symposium XIX, Spa, Belgium, June 8-13, 2014.

2014 "Avoiding Synchronization in Geometric Multigrid", SIAM Conference on Parallel Processing for Scientific Computing, Portland, Oregon, February 18-21, 2014.

2013 "Efficient Deflation for Communication-Avoiding Krylov Methods", Numerical Analysis and Scientific Computation with Applications, Calais, France, June 24-26, 2013.

2012 "Improving the Stability of Communication-Avoiding Krylov Subspace Methods", SIAM Conference on Applied Linear Algebra, Valencia, Spain, June 18-22, 2012.

2012 "Exploiting Low-Rank Structure in Computing Matrix Powers with Applications to Preconditioning", SIAM Conference on Parallel Processing for Scientific Computing, Savannah, Georgia, February 15-17, 2012.

2012 "A Residual Replacement Strategy for Improving the Maximum Attainable Accuracy of Communication-Avoiding Krylov Subspace Methods", 9th International Workshop on Accurate Solution of Eigenvalue Problems, Napa Valley, CA, June 4-7, 2012.

Honors and Awards

2017 **Householder Prize, Finalist**, July 2017.

2013 **Rising Stars in EECS**, *Selected Participant*, MIT, November 2013.

2010-2013 **National Defense Science and Engineering Graduate Fellowship**.

2009 **CRA Outstanding Undergraduate Research Award, Runner-up**.

2008 **Microsoft Technical Scholarship Award**.

2007 **Lockheed Martin Distinguished Scholar Award**.

2007 **Computing and Communications Scholarship for Undergraduate Women**, University of Virginia.

Professional Activities

2020 **Euro-Par 2020 Local Chair**, *Topic 9: "Parallel Numerical Methods and Applications".*

2019 **Minisymposium Co-organizer** (with J. Šístek and P. Arbenz), *"Numerical Methods for Massively Parallel Computations", Modelling 2019, Olomouc, Czech Republic, September 16-20, 2019.*

2019 **Minisymposium Co-organizer** (with A. Greenbaum), *"Roundoff Error in High-Performance Implementations of CG/Lanczos-type Solvers", SIAM Conference on Computational Science and Engineering, Spokane, Washington, February 25 - March 1, 2019.*

2019 **Primary Program Committee Member**, *Algorithms Track, IEEE International Parallel & Distributed Processing Symposium (IPDPS '19), Rio de Janeiro, Brazil, May 20-24, 2019.*

2018 **Program Committee Member**, *Technical Papers - Algorithms Track, IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '18), Dallas, USA, November 11-16, 2018.*

2018 **Program Committee Member**, *Doctoral Showcase, IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '18), Dallas, USA, November 11-16, 2018.*

2018 **Program Committee Member**, *SIAM Workshop on Combinatorial Scientific Computing (CSC18), Bergen, Norway, June 6-8, 2018.*

2018 **Minisymposium Co-organizer** (with S. Cools), *"Scalable Communication-Avoiding and -Hiding Krylov Subspace Methods", SIAM Conference on Parallel Processing for Scientific Computing, Tokyo, Japan, March 7-10, 2018.*

2017 **Minisymposium Organizer**, *MS76/93: "Communication-Avoiding Algorithms", SIAM Annual Meeting, Pittsburgh, USA, July 10-14, 2017.*

2016 **Program Committee Member**, *Technical Papers - Algorithms Track, IEEE International Conference for High Performance Computing, Networking, Storage and Analysis (Supercomputing '16), Salt Lake City, USA, November 13-18, 2016.*

2016 **Minisymposium Co-organizer** (with L. Grigori), *MS4: "Minimizing Communication in Numerical Algorithms", SIAM Conference on Parallel Processing for Scientific Computing, Paris, France, April 12-15, 2016.*

2015 **Minisymposium Organizer**, *MS58: "Approaches to Reducing Communication in Krylov Subspace Methods", SIAM Conference on Applied Linear Algebra, Atlanta, Georgia, October 26-30, 2015.*

2009–2015 **Feature Editor for ACM XRDS Magazine**, Association for Computing Machinery, New York, NY.
Lead Issue Editor for Diversity in Computer Science (V.20,4), Scientific Computing (V.19,3)

2014 **Organizing Committee member**, *Rising Stars in EECS Workshop*, UC Berkeley.

Teaching Experience

2019 **NMNV565: High Performance Computing for Computational Science**, Instructor, Charles University, Fall 2019.

2018 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2018.

2017 **MATH-UA 140: Linear Algebra**, Instructor, New York University, Fall 2017.

2017 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2017.

2016 **MATH-UA 120: Discrete Mathematics**, Instructor, New York University, Fall 2016.

2016 **DS-GA 1004: Big Data**, Instructor, New York University, Spring 2016.

2015 **MATH-UA 120: Discrete Mathematics**, Instructor, New York University, Fall 2015.

2014 **CS 70: Discrete Mathematics and Probability Theory**, Graduate Student Instructor. Instructor Anant Sahai, U.C. Berkeley, Fall 2014.

2012–2014 **Short Course on Parallel Computing**, Graduate Student Instructor. Instructor James Demmel, U.C. Berkeley, Summer 2012, 2013, and 2014.

2011 **Math 54: Linear Algebra and Differential Equations**, Graduate Student Instructor. Instructor Constantin Teleman, U.C. Berkeley, Spring 2011.

2009 **CS 202: Discrete Mathematics**, Teaching Assistant. Instructor Paul F. Reynolds, Jr., University of Virginia, Spring 2009.

2008 **CS 202: Discrete Mathematics**, Teaching Assistant. Instructor John Knight, University of Virginia, Fall 2008.

2008 **CS 101: Introduction to Computer Science**, Teaching Assistant. Instructor Tom Horton, University of Virginia, Fall 2008.

2008 **CS 101: Introduction to Computer Science**, Teaching Assistant. Instructors Kevin Sullivan and Greg Humphreys, University of Virginia, Spring 2008.

2007 **CS 101: Introduction to Computer Science**, Teaching Assistant. Instructors Kevin Sullivan and Greg Humphreys, University of Virginia, Fall 2007.

2007 **CS 101x: Introduction to Computer Science**, Teaching Assistant. Instructor Jim Cohoon, University of Virginia, Spring 2007.