Brittany Froese Hamfeldt

Contact Information

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Department of Mathematical Sciences
New Jersey Institute of Technology

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Research Interests

nonlinear partial differential equations, numerical analysis, finite difference methods, optimal transport, viscosity solutions, seismology, refractor and reflector design

Education

Simon Fraser University, Burnaby, BC, Canada September 2009 - July 2012
Doctor of Philosophy, Applied Mathematics
Advisor: Adam Oberman

Simon Fraser University, Burnaby, BC, Canada September 2007 - August 2009
Master of Science, Applied Mathematics
Advisor: Adam Oberman

Trinity Western University, Langley, BC, Canada, September 2003 - April 2007
Bachelor of Science, Mathematics
Advisor: Donald Ariel

Employment

New Jersey Institute of Technology, Newark, NJ, USA September 2020 - Present
Associate Professor, Department of Mathematical Sciences

New Jersey Institute of Technology, Newark, NJ, USA August 2015 - August 2020
Assistant Professor, Department of Mathematical Sciences

The University of Texas at Austin, Austin, TX, USA August 2012 - July 2015
Instructor, Department Mathematics
Postdoctoral Fellow, Institute for Computational Engineering and Sciences

Grants

NSF DMS-1751996 (sole PI), CAREER: Generated Jacobian equations in geometric optics and optimal transport, 2018-2023

NSF DMS-1619807 (sole PI), Meshfree finite difference methods for nonlinear elliptic equations, 2016-2019

Simons Foundation Collaboration Grant, 2016-2017

AWM Travel Grant, 2014

Awards

NJIT CSLA Excellence in Graduate Education Award	2020
NJIT CSLA Rising Star Research Award	2017
SFU Dean of Graduate Studies Convocation Medal	2013
NSERC Postdoctoral Fellowship	2012-2014
SIAM Student Paper Prize	2012
NSERC Alexander Graham Bell CGS-D	2010-2012
SFU Graduate Research Fellowship	2010
Pacific Century Graduate Scholarship	2009-2010
SFU Department of Mathematics Graduate Scholarship	2009

NSERC PGS-M Extension	2008-2009
SFU Graduate Research Fellowship	2008
NSERC PGS-M	2007-2008
SFU Special Graduate Entrance Scholarship	2007
Governor General's Silver Medal	2007

Preprints

Jake Brusca and Brittany Froese Hamfeldt. A convergent quadrature based method for the Monge-Ampère equation. https://arxiv.org/pdf/2205.03483.pdf

Brittany Froese Hamfeldt and Axel G. R. Turnquist. On the reduction in accuracy of finite difference schemes on manifolds without boundary. https://arxiv.org/pdf/2204.01892.pdf

Publications

Brittany Froese Hamfeldt and Axel G. R. Turnquist. A convergence framework for optimal transport on the sphere. *Numerische Mathematik*, in press.

Brittany Froese Hamfeldt and Jacob Lesniewski. A convergent finite difference method for computing minimal Lagrangian graphs. *Communications in Pure and Applied Analysis*, 21(2): 393-418, 2022.

Brittany Froese Hamfeldt and Jacob Lesniewski. Convergent finite difference methods for fully nonlinear elliptic equations in three dimensions. *Journal of Scientific Computing*, 90(35), 2022.

Brittany Froese Hamfeldt and Axel G. R. Turnquist. A convergent numerical method for the reflector antenna problem via optimal transport on the sphere. *Journal of the Optical Society of America A*, 38(11): 1704-1713, 2021.

Brittany Froese Hamfeldt and Axel G. R. Turnquist. A convergent finite difference method for optimal transport on the sphere. *Journal of Computational Physics*, 445(15), 2021.

Brittany Froese Hamfeldt. Convergence framework for the second boundary value problem for the Monge-Ampère equation. *SIAM Journal on Numerical Analysis*, 57(2), 945971, 2019.

Brittany Froese Hamfeldt and Tiago Salvador. Higher-order adaptive finite difference methods for fully nonlinear elliptic equations. *Journal of Scientific Computing*, 75(3): 1282-1306, 2018

Brittany Froese Hamfeldt. Convergent approximation of non-continuous surfaces of prescribed Gaussian curvature. *Communications on Pure and Applied Analysis*, 17(2): 671-707, 2018.

Yunan Yang, Björn Engquist, Junzhe Sun, and Brittany D. Froese. Application of optimal transport and the quadratic Wasserstein metric to full-waveform inversion. *Geophysics*, 83(1): R43-R62, 2018.

Brittany D. Froese. Meshfree finite difference approximations for functions of the eigenvalues of the Hessian. *Numerische Mathematik*, 138(1):75-99, 2018.

Zexin Feng, Brittany D. Froese, Rongguang Liang, Dewen Cheng, and Yongtian Wang.

Simplified freeform optics design for complicated laser beam shaping. *Applied Optics*, 56(33): 9308-9314, 2017.

Jean-David Benamou and Brittany D. Froese. Weak Monge-Ampère solutions of the semi-discrete optimal transportation problem. In *Topological Optimization: Optimal Transport in the Applied Sciences*, volume 17 of *Radon Series on Computational and Applied Mathematics*. De Gruyter: 175-203, 2017.

Jun Liu, Brittany D. Froese, Adam M. Oberman, and Mingqing Xiao. A multigrid scheme for 3D Monge-Ampère equations. *International Journal of Computer Mathematics*, 94(9):1850-1866, 2017.

Brittany D. Froese, Adam M. Oberman, and Tiago Salvador. Numerical methods for the 2-Hessian elliptic partial differential equation. *IMA Journal of Numerical Analysis*, 37(1):209-236, 2017.

Björn Enguist, Brittany D. Froese, and Yunan Yang. Optimal transport for seismic full waveform inversion. *Communications in Mathematical Sciences*, 14(8):2309-2330, 2016.

Zexin Feng, Brittany D. Froese, Chih-Yu Huang, Donglin Ma, and Rongguang Liang. Freeform illumination optics following an optimal transport map. *Applied Optics*, 55(16):4301-4306, 2016.

Zexin Feng, Brittany D. Froese, and Rongguang Liang. A composite method for precise freeform optical beam shaping. *Applied Optics*, 54(31):9364-9369, 2015.

Zexin Feng, Brittany D. Froese, Chih-Yu Huang, Donglin Ma, and Rongguang Liang. Creating unconventional geometric beams with large depth of field using double freeform-surface optics. *Applied Optics*, 54(20):6277-6281, 2015.

Björn Engquist, Brittany D. Froese, and Yen-Hsi Richard Tsai. Fast sweeping methods for hyperbolic systems of conservation laws at steady state II. *Journal of Computational Physics*, 286:70-86, 2015.

Björn Engquist and Brittany D. Froese. Application of the Wasserstein metric to seismic signals. *Communications in Mathematical Sciences*, 12(5):979-988, 2014.

Jean-David Benamou, Brittany D. Froese, and Adam M. Oberman. Numerical solution of the optimal transportation problem using the Monge-Ampère equation. *Journal of Computational Physics*, 260:107-126, 2014.

Björn Engquist, Brittany D. Froese, and Yen-Hsi Richard Tsai. Fast sweeping methods for hyperbolic systems of conservation laws at steady state. *Journal of Computational Physics*, 255:316-338, 2013.

Brittany D. Froese and Adam M. Oberman. Convergent filtered schemes for the Monge-Ampère partial differential equation. *SIAM Journal on Numerical Analysis*, 51(1):423-444, 2013.

Brittany D. Froese. A numerical method for the elliptic Monge-Ampère equation with transport boundary conditions. *SIAM Journal on Scientific Computing*, 34(3):A1432-A1459, 2012.

Brittany D. Froese and Adam M. Oberman. Convergent finite difference solvers for viscosity solutions of the elliptic Monge-Ampère equation in dimensions two and higher. *SIAM Journal on Numerical Analysis*, 49(4):1692-1714, 2011.

Brittany D. Froese and Adam M. Oberman. Fast finite difference solvers for singular solutions of the elliptic Monge-Ampère Equation. *Journal of Computational Physics*, 230(3):818-834, 2011.

Jean-David Benamou, Brittany D. Froese, and Adam M. Oberman. Two numerical methods for the elliptic Monge-Ampère Equation. *ESAIM: Mathematical Modelling and Numerical Analysis*, 44(4):737-758, 2010.

Brittany D. Froese and Adam M. Oberman. Numerical averaging of non-divergence structure elliptic operators. *Communications in Mathematical Sciences*, 7(4):785-804, 2009.

Reports

Brittany D. Froese. Generalised finite difference methods for Monge-Ampère equations. *Oberwolfach Report* 7: 42-45, 2017. https://www.mfo.de/occasion/1705

Jean-David Benamou, Brittany D. Froese, and Adam M. Oberman. Numerical solution of the second boundary value problem for the Monge-Ampère equation. *INRIA Report*, 2012. https://hal.inria.fr/hal-00703677/document

Theses

Numerical methods for the elliptic Monge-Ampère equation and optimal transport, Ph.D. Thesis, Simon Fraser University, 2012.

Numerical methods for two second order elliptic equations, Master's Thesis, Simon Fraser University, 2009.

Homotopy analysis method for axisymmetric flow of a power law fluid past a stretching sheet, Bachelor's Thesis, Trinity Western University, 2007.

Presentations

Full waveform inversion using the Wasserstein metric. *Machine Learning and Optimization Seminar*, NJIT, Newark, NJ (2021).

Numerical optimal transport on the sphere. *Applied Mathematics Seminar (Online)*, Johns Hopkins University, Baltimore, MD (2021).

Generalised finite difference methods for fully nonlinear elliptic equations. *Applied Mathematics Seminar (Online)*, UNC Greensboro, Greensboro, NC (2021).

Convergent numerical methods for Optimal Transport. *DMS Summer Seminars (Online)*, NJIT, Newark, NJ (2020).

Numerical methods for Optimal Transport. *Applied and Computational Math Colloquium (Online)*, University of Minnesota, Minneapolis, MN (2020).

Generalised finite difference methods for fully nonlinear elliptic equations. *Applied and Computational Math Seminar*, Rutgers University, Piscataway, NJ (2019).

A viscosity framework for solving the second boundary value problem for the Monge-Ampère equation. *Symposium on Monge-Ampère solvers with applications to illumina-*

tion optics, Eindhoven University of Technology, Eindhoven, Netherlands (2018).

Convergent numerical methods for the second boundary value problem for the Monge-Ampère equation. *Numerical Analysis Seminar*, U. Maryland, College Park, MD (2018).

Beam shaping using optimal transport. *Frontiers in Applied and Computational Mathematics*, Newark, NJ (2018).

Meshfree finite difference methods for fully nonlinear elliptic equations. *CAIMS Annual Meeting*, Toronto, ON, Canada (2018).

Generalised finite difference methods for fully nonlinear elliptic equations. *Mathematics Colloquium*, Southern Illinois University Edwardsville, Edwardsville, Il (2018).

Generalised finite difference methods for the Monge-Ampère equation. *SCICADE: Adaptivity and Moving Meshes*, Bath, UK (2017).

Applications of optimal transport and the Wasserstein metric. Chinese Academy of Sciences, Beijing, China (2017).

Generalised finite difference methods for the Monge-Ampère equation. Tsinghua University, Beijing, China (2017).

Applications of optimal transport and the Wasserstein metric. Tsinghua University, Beijing, China (2017).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Numerical Methods for PDEs and their Applications*, Insitut Mittag-Leffler, Djursholm, Sweden (2017).

Generalised finite difference methods for Monge-Ampère equations. *Generated Jacobian Equations: from Geometric Optics to Economics*, BIRS, Banff, AB, Canada (2017). http://www.birs.ca/events/2017/5-day-workshops/17w5078/videos/watch/201704101542-Froese.html

Numerical approximation of optimal transport maps via Monge-Ampère equtaions. *SIAM CSE Meeting: Computational Methods for Illumination Optics*, Atlanta, GA (2017).

Generalised finite difference methods for Monge-Ampère equations. *Applications of Optimal Transportation in the Natural Sciences*, MFO, Oberwolfach, Germany (2017).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Applied Mathematics Colloquium*, NJIT, Newark, NJ (2017).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Scientific Computing Seminar*, Brown University, Providence, RI (2016).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Applied Math & Analysis Seminar*, Duke University, Durham, NC (2016).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Numerical Analysis and Scientific Computing Seminar*, Courant Institute, New York, NY (2016).

Meshfree finite difference methods for the Monge-Ampère equation. *Computational Optimal Transportation*, Montreal, QC (2016).

Numerical optimal transportation using the Monge-Ampère equation. *Moving Mesh Methods*, Bath, UK (2016).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Mathematical Sciences Colloquium*, RPI, Troy, NY (2016).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Numerical Analysis Seminar*, U. Maryland, College Park, MD (2016).

Meshfree finite difference methods for fully nonlinear elliptic equations. *Applied and Computational Mathematics Seminar*, Georgia Tech, Atlanta, GA (2016).

Numerical optimal transportation using the Monge-Ampère equation. *Applied Mathematics Colloquium*, Columbia University, New York, NY (2016).

Numerical optimal transportation using the Monge-Ampère equation. *Analysis and Applied Mathematics Seminar*, UIC, Chicago, Il (2016).

Comparison of seismic signals using the Wasserstein metric. *Computational Seismology*, Sanya, China (2016).

Beam shaping using the Monge-Ampère equation. *MOKALIEN Meeting*, Paris, France (2015).

Numerical methods for fully nonlinear elliptic equations. *Numerical and Multiscale Issues for Partial and Integral Differential Equations*, Austin, TX (2015).

Meshfree finite difference methods for nonlinear elliptic equations. *Nonlinear PDEs, Numerical Analysis, and Applications*, Pittsburgh, PA (2015).

Fast sweeping methods for hyperbolic systems of conservation laws. *Frontiers in Applied and Computational Mathematics*, Newark, NJ (2015).

Linearisation of the Wasserstein metric. *TCCS Research Meeting*, Houston, TX (2015).

Higher-order filtered methods for nonlinear partial differential equations. *SIAM CSE Meeting: Efficient High-order Numerical Methods for Nonlinear PDEs*, Salt Lake City, UT (2015).

Recent developments in optimal transport. *TCCS Research Meeting*, Austin, TX (2014).

A viscosity framework for computing Aleksandrov solutions of the Monge-Ampère equation. *SIAM Annual Meeting: Numerical Methods for Viscosity Solutions and Applications*, Chicago, IL (2014).

An approximation scheme for Aleksandrov solutions of the Monge-Ampère equation. *CAIMS Meeting: Numerical Methods for Nonlinear PDEs*, Saskatoon, SK (2014).

Fast sweeping methods for hyperbolic systems of conservation laws. *Numerical Analysis Seminar*, KTH, Stockholm, Sweden (2014).

Numerical solution of the optimal transportation problem using the Monge-Ampère equation. *Numerical Analysis Seminar*, KTH, Stockholm, Sweden (2014).

Fast sweeping methods for hyperbolic systems of conservation laws. *Math/ICES Center of Numerical Analysis Seminar*, UT Austin, Austin, TX (2014).

Fast sweeping methods for hyperbolic systems of conservation laws. *Applied Mathematics Seminar*, McGill University, Montreal, QC (2014).

Application of the Wasserstein metric to seismic signals. *MOKAPLAN Seminar*, INRIA, Paris, France (2014).

Fast sweeping methods for hyperbolic systems of conservation laws at steady state. *Joint Mathematics Meeting: Special Session on Mathematics of Computation*, Baltimore, MD (2014).

Numerical solution of the optimal transportation problem using the Monge-Ampère equation. *CAAM Colloquium*, Rice University, Houston, TX (2014).

Finite difference methods for nonlinear elliptic equations with application to optimal transport. *Applied Mathematics Seminar*, GWU, Washington, DC (2013).

The Wasserstein metric and the Monge-Ampère equation. *TCCS Research Meeting*, Austin, TX (2013).

Numerical solution of the second boundary value problem for the Monge-Ampère equation. *Numerical Methods for Optimal Transportation*, BIRS, Banff, AB (2013).

Fast sweeping methods for systems of conservation laws. *AWM Research Symposium: Special Session on Numerical Methods for PDEs*, Santa Clara, CA (2013).

Numerical solution of the optimal transportation problem via viscosity solutions of the Monge-Ampère equation. *CCT Computational Mathematics Seminar*, LSU, Baton Rouge, LA (2013).

Numerical solution of the optimal transportation problem via viscosity solutions of the Monge-Ampère equation. *Math/ICES Center of Numerical Analysis Seminar*, UT Austin, Austin, TX (2012).

Convergent finite difference solvers for viscosity solutions of the elliptic Monge-Ampère equation in dimensions two and higher. *SIAM Annual Meeting: SIAM Student Paper Prize*, Minneapolis, MN (2012).

Numerical methods for the Monge-Ampère equation with transport boundary conditions. *ICIAM: Minisymposium on Numerical Methods for Monge-Ampère Equations and Optimal Transportation*, Vancouver, BC (2011).

A numerical method for the elliptic Monge-Ampère equation with transport boundary conditions. *Applied Analysis and PDEs*, Victoria, BC (2011).

Numerical methods for L^2 optimal transport using the Monge-Ampère equation. *Mathematics Colloquium*, WWU, Bellingham, WA (2011).

Numerical methods for L^2 optimal transport using the Monge-Ampère equation. *PIMS/CSC Seminar*, SFU, Burnaby, BC (2011).

Finite difference methods for viscosity solutions of the Monge-Ampère equation. *Joint Mathematics Meeting: Special Session on Mathematics of Computation*, New Orleans, LA (2011).

Numerical methods for the elliptic Monge-Ampère equation. *Monge-Kantorovich Optimal Transport - Theory and Applications*, Santa Fe, NM (2009).

Teaching

Assistant/Associate Professor (NJIT) Fall 2015 - Present

- MATH 111: Calculus I
- MATH 337: Linear Algebra
- MATH 480/545: Introductory Mathematical Analysis
- MATH 481/546: Advanced Calculus
- MATH 614: Numerical Methods I
- MATH 651: Methods of Applied Mathematics I
- MATH 707: Optimal Transport

Instructor (UT Austin) Fall 2012 - Spring 2015

- MATH 427K: Differential Equations
- MATH 427L: Vector Calculus
- MATH 348: Scientific Computing in Numerical Analysis

Substitute Lecturer (SFU) Summer 2009 - Fall 2011

- MATH 150: Calculus I
- MATH 242: Introduction to Analysis
- MACM 316: Numerical Analysis I
- APMA 922: Numerical PDEs

Service

Programming
With Jeff Wiens, I released an open source Matlab implementation of the immersed boundary method (IBM). This is designed to be used as a tool for training students and a starting point for research projects involved the IBM. Available at https://github.com/eldila/MatIB.

Reviewer for

- *Numerische Mathematik*
- *Mathematics of Computation*
- *SIAM Journal on Numerical Analysis*
- *SIAM Journal on Scientific Computing*

- *SIAM Journal on Mathematical Analysis*
- *Journal of Scientific Computing*
- *Journal of Computational Physics*
- *Communications in Mathematical Sciences*
- *Journal of Optimization Theory and Applications*
- *IMA Journal of Applied Mathematics*
- *IMA Journal of Numerical Analysis*
- *European Journal of Applied Mathematics*
- *Mathematical Programming*
- *Mathematical Modelling and Numerical Analysis*
- *Computers and Mathematics with Applications*
- *Journal of Nonlinear Science*
- *Journal of Numerical Mathematics*
- *Computer Methods in Applied Mechanics and Engineering*
- *Journal of Computational and Applied Mathematics*
- *Journal of the Optical Society of America A*
- *Partial Differential Equations and Applications*
- *Optics Express*
- *Numerical Algorithms*
- *Symmetry*
- *UT Undergraduate Research Journal*

Proposal Review for

- Swiss National Science Foundation
- Simons Foundation

Advisor for

- Math minors, NJIT (Sept 2015 - Present)

Co-organiser of

- *FACM: Minisymposium on Optimal Transport with Industrial Applications*, Newark, NJ (2017).
- *Applied Mathematics Graduate Student Conference*, Burnaby, BC (2009).

Speaker for

- UT Austin Student Chapter of Association for Women in Mathematics (2013).

Mentor for

- Girls Who Code Mentoring Event, NJIT (2017).

Judge for

- *Dana Knox Research Showcase*, NJIT, Newark, NJ (2018).
- *Dana Knox Research Showcase*, NJIT, Newark, NJ (2017).
- *Dana Knox Research Showcase*, NJIT, Newark, NJ (2016).
- *College of Natural Sciences Undergraduate Research Forum*, UT Austin, Austin, TX (2013).