Jeff Calder

February, 2024

538 Vincent Hall
School of Mathematics
University of Minnesota

Email: jcalder@umn.edu
Web: http://www.math.umn.edu/~jwcalder/

Research Interests

Analysis of partial differential equations, viscosity solutions, numerical analysis, applied probability, machine learning, graph-based learning, image processing and computer vision

Appointments

2023–2028	Albert and Dorothy Marden Professor, University of Minnesota
2021–present	Associate Professor, University of Minnesota
2016–2021	Assistant Professor, University of Minnesota
March–June, 2020	Visiting Fellow, Institute for Pure and Applied Mathematics
2014–2016	Morrey Assistant Professor, University of California, Berkeley Mentors: Lawrence C. Evans and James Sethian

Education

2010–2014	Ph.D. in Applied Mathematics, University of Michigan, Ann Arbor Advisors: Selim Esedoḡlu and Alfred Hero
2008–2010	M.Sc. in Mathematics, Queen's University, Kingston, Ontario, Canada Advisor: Professor Abdol-Reza Mansouri
2003–2008	B.Sc. in Mathematics and Engineering with Professional Internship, Queen's University

Awards

1. Albert and Dorothy Marden Professorship, 2023.
2. McKnight Presidential Fellow, 2021.
3. University of Minnesota Guillermo E. Borja Award, 2021.
4. Alfred P. Sloan Research Fellowship in Mathematics, 2020.

Grants

1. PI (co-PIs Georgios Giannakis and Zhi-Li Zhang): *Analytical Foundations for Deep Learning and Inference over Graphs.* MoDL+ NSF-CCF:2212318, 2022–2025 ($1,199,788).
2. co-PI (with Rajesh Rajamani and Zhi-Li Zhang): *Towards Edge-assisted Intelligent Driving: Cooperative Learning for Low-Latency V2I Communications & AV Remote Control*, CSE InterS&Ections Seed Grant, 2022–2024 ($200,000).
3. PI: NSF Career Grant: *Harnessing the Continuum for Big Data: Partial Differential Equations, Calculus of Variations, and Machine Learning.* NSF-DMS:1944925, 2020–2025 ($429,999).

4. co-PI (with Peter Olver): *Geometric Analysis for Classification and Reassembly of Broken Bones.* NSF-DMS:1816917, 2018–2021 ($418,069).

5. PI: *Partial Differential Equation Continuum Limits in Machine Learning and Applications.* Grant in Aid, University of Minnesota ($44,000).

6. PI: *Industrial Research Collaboration.* Corning Inc., 2018–2019 ($69,603).

7. PI: *Nonlinear Partial Differential Equations, Monotone Numerical Schemes, and Scaling Limits for Semi-Supervised Learning on Graphs.* NSF-DMS:1713691, 2017–2020 ($163,136).

8. PI: *Nonlinear Partial Differential Equations and Continuum Limits for Large Discrete Sorting Problems.* NSF-DMS:1500829, 2015–2017 ($76,362).

Software

1. J. Calder. GraphLearning Python Package. `doi:10.5281/zenodo.5850940`, 2022. [Code]

Publications

1. J. Calder and N. Drenska. Consistency of semi-supervised learning, stochastic tug-of-war games, and the p-Laplacian. *arXiv:2401.07463*, 2024. [arXiv], [Code]

2. L. Bungert, J. Calder, and T. Roith. Ratio convergence rates for Euclidean first-passage percolation: Applications to the graph infinity Laplacian. *To appear in Annals of Applied Probability*, 2023. [arXiv], [Code]

3. K. Yezzi-Woodley, A. Terwilliger, J. Li, E. Chen, M. Tappen, J. Calder, and P. J. Olver. Using machine learning on new feature sets extracted from 3D models of broken animal bones to classify fragments according to break agent. *To appear in Journal of Human Evolution*, 2023. [arXiv], [Code]

4. J. Calder and W. Lee. Monotone discretizations of levelset convex geometric PDEs. *arXiv:2310.08450*, 2023. [arXiv], [Code]

5. K. Miller and J. Calder. Poisson Reweighted Laplacian Uncertainty Sampling for Graph-based Active Learning. *SIAM Journal on Mathematics of Data Science*, 5, 2023. [arXiv], [Journal], [Code]

6. J. Enwright, H. Hardiman-Mostow, J. Calder, and A. L. Bertozzi. Deep semi-supervised label propagation for SAR image classification. *SPIE Defense and Commercial Sensing: Algorithms for Synthetic Aperture Radar Imagery XXX*, 2023. [Journal], [pdf], [Code]

7. J. Chapman, B. Chen, Z. Tan, J. Calder, K. Miller, and A. L. Bertozzi. Novel Batch Active Learning Approach and Its Application on the Synthetic Aperture Radar Datasets. *SPIE Defense and Commercial Sensing: Algorithms for Synthetic Aperture Radar Imagery XXX (Best Student Paper)*, 2023. [Journal], [pdf], [Code]

8. J. Brown, R. O'Neill, J. Calder, and A. L. Bertozzi. Utilizing Contrastive Learning for Graph-Based Active Learning of SAR Data. *SPIE Defense and Commercial Sensing: Algorithms for Synthetic Aperture Radar Imagery XXX*, 2023. [Journal], [pdf], [Code]

9. J. Calder, D. Slepčev, and M. Thorpe. Rates of convergence for Laplacian semi-supervised learning with low labeling rates. *Research in Mathematical Sciences special issue on PDE methods for machine learning*, 10(10), 2023. [arXiv], [Journal]

10. J. Calder and M. Ettehad. Hamilton-Jacobi equations on graphs with applications to semi-supervised learning and data depth. *Journal of Machine Learning Research*, 23(318):1–62, 2022. [arXiv], [Journal], [Code]

11. J. Calder, R. Coil, A. Melton, P. J. Olver, G. Tostevin, and K. Yezzi-Woodley. Use and Misuse of Machine Learning in Anthropology. *IEEE BITS special issue on Information Processing in Arts and Humanities*, 2022. [arXiv], [Journal]

12. L. Bungert, J. Calder, and T. Roith. Uniform Convergence Rates for Lipschitz Learning on Graphs. *IMA Journal of Numerical Analysis*, 2022. [arXiv], [Journal], [Code]

13. J. Calder, S. Park, and D. Slepčev. Boundary Estimation from Point Clouds: Algorithms, Guarantees and Applications. *Journal of Scientific Computing*, 92(2):1–59, 2022. [arXiv], [Journal], [Code]

14. K. Yezzi-Woodley, J. Calder, M. Sweno, C. Siewert, and P. J. Olver. The Batch Artifact Scanning Protocol: A new method using computed tomography (CT) to rapidly create three-dimensional models of objects from large collections en masse. *arXiv:2205.02691*, 2022. [arXiv], [Code]

15. A. Yuan, J. Calder, and B. Osting. A continuum limit for the PageRank algorithm. *European Journal of Applied Mathematics*, 33:472–504, 2022. [arXiv], [Journal], [Code]

16. N. Drenska and J. Calder. Online prediction with history-dependent experts: The general case. *Communications on Pure and Applied Mathematics*, 76, 2022. [arXiv], [Journal]

17. K. Miller, X. Baca, J. Mauro, J. Setiadi, Z. Shi, J. Calder, and A. Bertozzi. Graph-based active learning for semi-supervised classification of SAR data. *SPIE Defense and Commercial Sensing: Algorithms for Synthetic Aperture Radar Imagery XXIX*, 12095, 2022. [arXiv], [Journal], [Code]

18. J. Calder and N. García Trillos. Improved spectral convergence rates for graph Laplacians on ε-graphs and k-NN graphs. *Applied and Computational Harmonic Analysis*, 60:123–175, 2022. [arXiv], [Journal], [Code]

19. J. Calder, N. García Trillos, and M. Lewicka. Lipschitz regularity of graph Laplacians on random data clouds. *SIAM Journal on Mathematical Analysis*, 54(1):1169–1222, 2022. [arXiv], [Journal]

20. M. Flores, J. Calder, and G. Lerman. Analysis and algorithms for Lp-based semi-supervised learning on graphs. *Applied and Computational Harmonic Analysis*, 60:77–122, 2022. [arXiv], [Journal], [Code]

21. B. Cook and J. Calder. Rates of convergence for the continuum limit of nondominated sorting. *SIAM Journal on Mathematical Analysis*, 54(1):872–911, 2022. [arXiv], [Journal]

22. K. Yezzi-Woodley, J. Calder, P. J. Olver, A. Melton, P. Cody, T. Huffstutler, A. Terwilliger, G. Tostevin, M. Tappen, and R. Coil. The Virtual Goniometer: A new method for measuring angles on 3D models of fragmentary bone and lithics. *Archaeological and Anthropological Sciences*, 13(106), 2021. [arXiv], [Journal], [Code]

23. J. Calder and N. Drenska. Asymptotically optimal strategies for online prediction with history-dependent experts. *Journal of Fourier Analysis and Applications Special Collection on Harmonic Analysis on Combinatorial Graphs*, 27(20), 2021. [arXiv], [Journal]

24. J. Calder, B. Cook, M. Thorpe, and D. Slepčev. Poisson Learning: Graph based semi-supervised learning at very low label rates. *Proceedings of the 37th International Conference on Machine Learning, PMLR*, 119:1306–1316, 2020. [arXiv], [Journal], [Code]

25. J. Calder and C. K. Smart. The limit shape of convex hull peeling. *Duke Mathematical Journal*, 169(11):2079–2124, 2020. [arXiv], [Journal]

26. J. Calder and D. Slepčev. Properly-weighted graph Laplacian for semi-supervised learning. *Applied Mathematics and Optimization*, 82:1111–1159, 2020. [arXiv], [Journal]

27. R. O'Neill, P. Angulo-Umana, J. Calder, B. Hessburg, P. J. Olver, C. Shakiban, and K. Yezzi-Woodley. Computation of circular area and spherical volume invariants via boundary integrals. *SIAM Journal on Imaging Sciences*, 13(1):53–77, 2020. [arXiv], [Journal], [Code]

28. M. Benyamin, J. Calder, G. Sundaramoorthi, and A. Yezzi. Accelerated variational PDE's for efficient solution of regularized inversion problems. *Journal of Mathematical Imaging and Vision*, 62(1):10–36, 2020. [arXiv], [Journal]

29. J. Calder and A. Yezzi. PDE Acceleration: A convergence rate analysis and applications to obstacle problems. *Research in the Mathematical Sciences*, 6(35), 2019. [arXiv], [Journal], [Code]

30. J. Calder. Consistency of Lipschitz learning with infinite unlabeled data and finite labeled data. *SIAM Journal on Mathematics of Data Science*, 1(4):780–812, 2019. [arXiv], [Journal], [Code]

31. C. Finlay, B. Abbasi, J. Calder, and A. M. Oberman. Lipschitz regularized Deep Neural Networks generalize and are adversarially robust. *arXiv:1808.09540*, 2018. [arXiv]

32. J. Calder. The game theoretic p-Laplacian and semi-supervised learning with few labels. *Nonlinearity*, 32(1):301–330, 2018. [arXiv], [Journal]

33. T. Gangwar, J. Calder, T. Takahashi, J. Bechtold, and D. Schillinger. Robust variational segmentation of 3D bone CT data with thin cartilage interfaces. *Medical Image Analysis*, 47:95–110, 2018. [Journal], [pdf]

34. B. Abbasi, J. Calder, and A. M. Oberman. Anomaly detection and classification for streaming data using partial differential equations. *SIAM Journal on Applied Mathematics*, 78(2):921–941, 2018. [arXiv], [Journal]

35. W. Thawinrak and J. Calder. High-order filtered schemes for the Hamilton-Jacobi continuum limit of nondominated sorting. *Journal of Mathematics Research*, 10(1):90–109, 2018. [arXiv], [Journal]

36. J. Calder. Numerical schemes and rates of convergence for the Hamilton-Jacobi equation continuum limit of nondominated sorting. *Numerische Mathematik*, 137(4):819–856, 2017. [arXiv], [Journal]

37. J. Calder. A direct verification argument for the Hamilton-Jacobi equation continuum limit of nondominated sorting. *Nonlinear Analysis Series A: Theory, Methods, & Applications*, 141:88–108, 2016. [arXiv], [Journal], [pdf]

38. K.-J. Hsiao, K. Xu, J. Calder, and A. O. Hero. Multi-criteria similarity-based anomaly detection using Pareto Depth Analysis. *IEEE Transactions on Neural Networks and Learning Systems*, 27(6):1307–1321, 2016. [arXiv], [Journal]

39. K.-J. Hsiao, J. Calder, and A. O. Hero. Pareto-depth for multiple-query image retrieval. *IEEE Transactions on Image Processing*, 24(2):583–594, 2015. [arXiv], [Journal], [pdf]

40. J. Calder. Directed last passage percolation with discontinuous weights. *Journal of Statistical Physics*, 158(45):903–949, 2015. [arXiv], [Journal], [pdf]

41. J. Calder, S. Esedoḡlu, and A. O. Hero. A PDE-based approach to nondominated sorting. *SIAM Journal on Numerical Analysis*, 53(1):82–104, 2015. [arXiv], [Journal], [pdf]

42. J. Calder, S. Esedoḡlu, and A. O. Hero. A continuum limit for non-dominated sorting. *Information Theory and Applications Workshop*, 2014. [Journal], [pdf]

43. J. Calder, S. Esedoḡlu, and A. O. Hero. A Hamilton-Jacobi equation for the continuum limit of nondominated sorting. *SIAM Journal on Mathematical Analysis*, 46(1):603–638, 2014. [arXiv], [Journal], [pdf]

44. K.-J. Hsiao, K. Xu, J. Calder, and A. O. Hero. Multi-criteria anomaly detection using Pareto Depth Analysis. *Advances in Neural Information Processing Systems 25*, pages 854–862, 2012. [arXiv], [Journal]

45. J. Calder and S. Esedoḡlu. On the circular area signature for graphs. *SIAM Journal on Imaging Sciences*, 5(4):1355–1379, 2012. [Journal], [pdf]

46. J. Calder and A.-R. Mansouri. Anisotropic image sharpening via well-posed Sobolev gradient flows. *SIAM Journal on Mathematical Analysis*, 43(4):1536–1556, 2011. [Journal], [pdf]

47. J. Calder, A.-R. Mansouri, and A. Yezzi. New possibilities in image diffusion and sharpening via high-order Sobolev gradient flows. *Journal of Mathematical Imaging and Vision*, 40(3):248–258, 2011. [Journal], [pdf]

48. J. Calder, A. M. Tahmasebi, and A.-R. Mansouri. A variational approach to bone segmentation in CT images. *SPIE Medical Imaging*, 7962, 2011. [Journal], [pdf]

49. J. Calder, A.-R. Mansouri, and A. Yezzi. Image sharpening via Sobolev gradient flows. *SIAM Journal on Imaging Sciences*, 3(4):981–1014, 2010. [Journal], [pdf]

50. R. Deriche, J. Calder, and M. Descoteaux. Optimal real-time Q-ball imaging using regularized Kalman filtering with incremental orientation sets. *Medical Image Analysis*, 13(4):564–579, 2009. [Journal], [pdf]

51. R. Deriche and J. Calder. Real-time magnetic resonance Q-ball imaging using Kalman filtering with Laplace-Beltrami regularization. *SPIE Medical Imaging*, 7259, 2009. [Journal], [pdf]

52. **Patent:** A. L. Bertozzi, K. Miller, and J. Calder. Systems and Methods for Graph-Based Active Learning for Semi-Supervised Classification of SAR Data, 2022. U.S. Provisional Patent Application No. 63/362,385 filed April 1, 2022

53. **Patent:** D. Schillinger, T. Gangwar, T. Takahashi, and J. Calder. Two-stage variational image segmentation of medical images using fracture mechanics, 2020. U.S. Patent Application 16/701,562, filed June 4, 2020

54. **Patent:** J. Calder and T. Sun. Efficient implementation of branch intensive algorithms in VLIW and superscalar processors, 2011. US Patent Number 8019979, Issued on September 13, 2011

Lecture Notes

1. J. Calder. Mathematics of Image and Data Analysis. *Online Lecture Notes*, 2021. [pdf]

2. J. Calder. The Calculus of Variations. *Online Lecture Notes*, 2020. [pdf]

3. J. Calder. Lecture Notes on Viscosity Solutions. *Online Lecture Notes*, 2018. [pdf]

Talks

1. AMS Special Session on the Geometry of the Shape Space, Joint Mathematics Meeting, 2024.

2. Applied Math Seminar, Boeing Applied Math, November, 2023.

3. Analysis Seminar, University of Texas at Austin, November, 2023.

4. Mathematics Colloquium, Michigan State University, October, 2023.

5. Minisymposium on Numerical methods for Hamilton-Jacobi equations and their applications, International Congress on Industrial and Applied Mathematics, Tokyo, Japan, August, 2023.

6. Sampling Theory and Applications Conference, Yale University, July 2023.

7. Foundations of Numerical PDEs Workshop, Foundations of Computational Mathematics Meeting, June 2023.

8. Applied Mathematics Colloquium, Columbia University, April 2023

9. Mathematics Colloquium, Carnegie Mellon University, January 2023.
10. Special Session on Data Science at the Crossroads of Analysis, Geometry, and Topology, Joint Mathematics Meeting, January 2023.
11. Reunion Workshop on High Dimensional Hamilton-Jacobi Equations, Institute for Pure and Applied Mathematics, December 2022.
12. Scientific Computing and Numerics (SCAN) Seminar, Cornell University, October, 2022.
13. Minisymposium on Graphs, Geometry, PDEs, and Learning, SIAM Conference on the Mathematics of Data Science, September 2022.
14. Minisymposium on Advances in Variational Methods and Applications to Materials and Machine Learning, SIAM Annual Meeting, July 2022.
15. Mathematical Data Science Seminar, Purdue University, April 2022.
16. Mathematics Colloquium, University of Utah, April 2022.
17. Minisymposium on the geometry of PDEs on graphs: Analysis and Applications, SIAM Conference on Analysis of PDEs, March 2022.
18. Hamilton-Jacobi PDEs Reunion Conference I, Institute for Pure and Applied Mathematics, January 2022.
19. Applied Mathematics Seminar, University of Texas at San Antonio, November 2021.
20. Workshop on Dynamics and Discretization: PDEs, Sampling, and Optimization, Simons Institute for the Theory of Computing, October 2021.
21. IMA Data Science Seminar, University of Minnesota, September 2021.
22. ICMS Workshop on Analytic and Geometric Approaches to Machine Learning, University of Bath, July 2021.
23. Seminar on the Mathematics of Deep Learning, Friedrich-Alexander-Universität (FAU) Erlangen-Nürnberg, May 2021.
24. Applied Mathematics Seminar, Courant Institute, New York University, April 2021.
25. Nonlinear Analysis Seminar, Rutgers University, April 2021
26. One World Seminar Series on the Mathematics of Machine Learning, March 2021.
27. Stochastics and PDEs Seminar, University of Jyväskylä, March 2021.
28. Computational and Applied Mathematics Seminar, Tufts University, March 2021.
29. Minisymposium on Theory and Applications of Graph-Based Learning, SIAM Conference on Computational Science and Engineering, March, 2021.
30. Applied Mathematics Colloquium, New Jersey Institute of Technology, January 2021.
31. Mathematics Colloquium, University of Toronto, January 2021.
32. CSE/DTC Machine Learning Seminar, University of Minnesota, September 2020.
33. Mathematics Colloquium, University of Minnesota, September 2020.
34. Mathematics in Imaging, Data and Optimization Seminar, Rensselear Polytechnic Institute (RPI), September 2020.

35. 37th International Conference on Machine Learning (ICML), July 2020

36. Workshop on Stochastic Analysis Related to Hamilton-Jacobi PDEs, Institute for Pure and Applied Mathematics, May 2020

37. Workshop on PDE and Inverse Problem Methods in Machine Learning, Institute for Pure and Applied Mathematics, April 2020

38. Opening day talk on *New directions in graph-based learning*, IPAM program on High Dimensional Hamilton-Jacobi PDEs, March 2020

39. Center for Nonlinear Analysis Seminar, Carnegie Mellon University, March 2020

40. Minisymposium on PDEs in Machine Learning, SIAM Conference on Analysis of PDEs, December 2019.

41. Applied Math and Analysis Seminar, Duke University, November 2019.

42. Workshop on Deep Learning and Partial Differential Equations, American Institute of Mathematics, October 2019.

43. Workshop on Recent Progress in Foundational Data Science Workshop, Institute for Mathematics and its Applications, September 2019.

44. Minisymposium on Nonlocal Methods in Image and Data Analysis, International Congress on Industrial and Applied Mathematics, Valencia, Spain, July 2019.

45. Symposium on Computational Modeling and Image Processing of Biomedical Problems, Michigan Technological University, June 2019.

46. Applied and Computational Analysis Seminar, University of Cambridge, June 2019.

47. Workshop on Inverse Problems and Machine Learning, Center de reserches mathematiques, Montreal, Canada, May 2019.

48. Corning Corporation, February 2019.

49. Center for Nonlinear Analysis Seminar, Carnegie Mellon University, November 13, 2018.

50. Session on Effective Behavior in Random Environments, AMS Sectional Meeting, Northeastern University, April 21, 2018.

51. Probability Seminar, University of Minnesota, April 20, 2018.

52. PDE Geometric Analysis Seminar, University of Wisconsin-Madison, April 9, 2018.

53. Mini-symposium on Partial Differential Equations in Machine Learning and Data Science, SIAM Conference on the Analysis of PDEs, December, 2017.

54. Center for Scientific Computation and Mathematical Modeling, University of Maryland, November 2017.

55. Workshop on Generative Models, Parameter Learning and Sparsity, Isaac Newton Institute for Mathematical Sciences, Cambridge, UK, November 2017.

56. Cargill Corporation, November 2017.

57. Target Corporation, October 2017.

58. Conference on Nonlinear Partial Differential Equations and the Calculus of Variations, UC Berkeley, May 2017.

59. IMA Data Science Seminar, University of Minnesota, March 7, 2017.

60. Center for Applied Mathematics Colloquium, Cornell University, Ithaca, February 24, 2017.
61. Probability Seminar, University of Minnesota, February 3, 2017.
62. Department of Industrial and Systems Engineering Seminar, University of Minnesota, January 25, 2017.
63. Center for Nonlinear Analysis Seminar, Carnegie Mellon University, Pittsburgh, March 31, 2016.
64. Applied Math Colloquium, University of California, Los Angeles, January 20, 2016.
65. Level Set Collective, University of California, Los Angeles, January 19, 2016.
66. Computational, Applied Mathematics and PDE seminar, University of Chicago, November 24, 2015.
67. Mathematics Colloquium, University of Minnesota, November 19, 2015.
68. Applied Mathematics Seminar, McGill University, September 9, 2015.
69. Mathematical Foundations for Fast Multi-resolution Interactions and Large Data Analysis, Duke University, August 29, 2015.
70. Mathematics and Computer Science Colloquium, Santa Clara University, May 26, 2015.
71. Analysis and PDE Seminar, UC Berkeley, February 2, 2015.
72. Applied Mathematics Seminar, McGill University, January 12, 2015.
73. Minisymposium on *Numerical Methods for Viscosity Solutions and Applications*, SIAM Annual Meeting, July 8, 2014.
74. Differential Equations Seminar, University of Michigan, February 6, 2014.
75. Contributed session on Hamilton-Jacobi Equations and First-order Systems, SIAM Conference on Analysis of PDE, December 10, 2013.
76. Analysis and Applied Mathematics Seminar, University of Toronto, November 8, 2013.
77. Mathematics Colloquium, Queen's University, October 29, 2013.
78. Minisymposium on Recent Developments in Numerical Methods for PDEs, SIAM Annual Meeting, July 12, 2013.
79. Applied Mathematics Seminar, University of California, Los Angeles, May 6, 2013.
80. Workshop on PDE in the social and life sciences: Emergent challenges in modeling, analysis, and computation, Banff International Research Station, April 1, 2013.
81. Inverse Problems and Image Analysis Seminar, Fields Institute for Research in Mathematical Sciences, University of Toronto, December 14, 2012.
82. SIAM Conference on Imaging Science, May 22, 2012.

Mentoring and supervision

PhD students

Current

- Irene Noharinaivo
- Riley O'Neill (co-advised with Peter Olver)
- Kodjo Houssou
- William (Ty) Frazier (co-advised with Richard McGehee).
- Kaelyn S. Willingham (co-advised with Gregg Musiker).

Former

- Brendan Cook, graduated 2022. Thesis title: "Two applications of PDE in data science". First position: Machine learning researcher at Meta.
- Drisana Mosaphir, graduated 2022. Thesis title: "Numerical analysis of prediction with expert advice". First Position: Machine learning engineer at Defense Contractor SIFT.
- Amber Yuan, PhD, graduated December 2021. Thesis title: "Two Problems Involving Random Walks on Graphs: Random surfers, PageRank, and short-time asymptotics for the heat kernel". First position: Machine Learning Engineer at Spotify.
- Mauricio Flores Rios (co-advised with Gilad Lerman), PhD, graduated December 2018. Thesis title: "Algorithms for ℓ_p-based semi-supervised learning on graphs". First position: Lead Data Scientist at Target Corporation.

Postdocs

Current

- Jingcheng Lu, 2023–2026.
- Wonjun Lee, IMA/NIST postdoc 2022–2025.

Former

- Mahmood Ettehad, IMA/Target postdoc 2020–2022. First position: Postdoc at the University of Colorado, Boulder.
- Shannon Negaard, IMA/Cargill postdoc 2019–2021. First position: Data scientist at NextEra Energy.
- Nadejda Drenska, MCFAM postdoc 2018-2021. First position: Rufus Isaacs Postdoctoral Fellow in the Department of Applied Mathematics and Statistics at Johns Hopkins University.

Undergraduate students

- Faculty mentor for Research Experience for Undergraduates (REU) program at UCLA in Summer 2021 (co-mentored with Andrea Bertozzi and Kevin Miller). The project was focused on graph-based active learning and resulted in a conference paper in the SPIE Conference on Algorithms for Synthetic Aperture Radar Imagery 2022.
- Faculty mentor (with Peter Olver) for REU for (current students) Alex Terwilliger and David Floeder (past students) Jiafeng Li, Paige Cody, Riley O'Neill, Thomas Huffstutler, Jacob Theis, Pedro Angulo-Umana, Jacob Elafandi, Bo Hessburg, Meredith Shipp. The project is focused on reassembly and classification of broken bone fragments in an archaeological context and has been ongoing since 2017.

- Undergraduate senior honors theses.
    1. David Floeder, Fall 2021–Spring 2022: Class balancing in graph-based learning.
    2. Atef Ali, Fall 2021–Spring 2022: p-Laplace extension of Poisson learning.
    3. Alex Zheng, Fall 2021–Spring 2022: Adversarial attacks in graph-based learning.
    4. Dingjun Bian, Fall 2020–Spring 2021: High-order Poisson learning for graph-based semisupervised learning.
    5. Jacob Elafandi, Fall 2018–Spring 2019: Fast marching-type algorithms for detecting fracture edges on broken bone fragments.
- Undergraduate senior projects.
    1. Urbas Ekka, Fall 2023, Community detection on networks.
    2. Mya Otto, Spring 2023: The Fundamentals of PID Control.
    3. Xiao Tan, Spring 2023: The PageRank Algorithm.
    4. Neil Chen, spring 2023: Classification of images of breast cancer.
    5. Isaiah Miller, Fall 2023: NFL Quarterback Salary Linear Regression Analysis.
    6. Kyle Schertler, Fall 2023: Weather and its affects on crime.
    7. Pavel Boulgakov, Fall 2023: Graph Convolutional Networks for Molecular Property Prediction.
    8. Tanner Skluzacek, Spring 2022: Contrastive learning.
    9. Vishnu Chhabra, Spring 2022: Graph Convolutional Neural Networks.
    10. Vaishnavi Narayanan, Spring 2022: Rotationally equivariant convolutional neural networks.
    11. Quinten Norton, Spring 2021: Adversarial attacks on Poisson learning.
    12. Guangqi Li, Spring 2021: Deep learning for image classification.
    13. Bella Li, Spring 2021: Deep learning for image classification.
    14. Zongliang Han, Fall 2020: Graph-based semi-supervised learning with label corruption.
    15. Alexander Djanin, Fall 2020: Deep convolutional neural networks for image classification.
    16. John Chrostek, Spring 2019: Survey of machine learning and experimentation in Python.
    17. Jessica Archerd, Spring 2019: Mathematics of Sudoku.
    18. Quincy Gu, Fall 2018: Multi-grid method for solving elliptic partial differential equations.
    19. Alexander Luetzow, Summer 2018: Deep learning and applications to classification of MNIST digits.
    20. Zheran Li, Fall 2017: Spectral graph theory and applications in machine learning.
    21. Hoang Nguyen, Fall 2017: Fast approximate convex hull algorithms.
    22. Jacob Warhol, Spring 2017: Asymptotic fluctuations in convex hull peeling.
    23. Jessica Nadalin, Fall 2014: Compressed sensing for functional magnetic resonance imaging (fMRI), UC Berkeley.
    24. Euijae Kim, Fall 2014: Partial differential equations for image processing, UC Berkeley.
- Undergraduate Research Opportunities Program (UROP) awards.
    1. Jason Setiadi, Fall 2021 & Spring 2022: Graph-based active learning.
    2. Vismay Mehta, Fall 2021: Comparison of graph convolutional neural networks (GCN) and Poisson learning.
    3. Siqi Ke, Spring 2021: Application of Poisson learning to image co-segmentation.
    4. Jiafeng Li, Summer 2020: Applications of machine learning to classification of broken bone fragments.

5. Warut Thawinrak, Summer 2017. High order filtered schemes for Hamilton-Jacobi equations.

- Directed reading courses.

1. Yi Zhang, Fall 2021: Graph Convolutional Neural Networks.
2. William Frazier, Fall 2020: Physics-Informed Neural Networks.
3. Ho Fai Matthew Mok, Spring 2015: Optimal control and Pontryagin's maximum principle, UC Berkeley.

High school students

- Fall 2021–present: Faculty mentor for Eric Chen through the Honors Mentor Connection class at Wayzata High School. Eric is working on applying graph-based methods in machine learning to the classification of broken bone fragments.
- Spring 2021–present: Faculty co-mentor (with Peter Olver, Katrina Yezzi-Woodley, Annie Melton) to Emily Liu, Wayzata High School. Emily is working on validating virtual angle measurement tools in anthropology.

Teaching

Regular courses

- Spring 2024: Math 5466 – Mathematics of Machine Learning and Data Analysis II
- Fall 2023: Math 5465 – Mathematics of Machine Learning and Data Analysis I
- Spring 2022: Math 5467 – Introduction to the Mathematics of Image and Data Analysis
- Spring 2021: Math 5467 – Introduction to the Mathematics of Image and Data Analysis
  - *Thank a Teacher* award from the Center for Educational Innovation, UMN.
- Fall 2019: Math 8385 – Calculus of Variations and Minimal Surfaces
- Spring 2019: Math 1272 – Calculus II
- Fall 2018: Math 8590 – Topics in Partial Differential Equations: Viscosity Solutions, University of Minnesota
- Fall 2017: Math 8583 – Partial Differential Equations I, University of Minnesota
- Spring 2017: Math 5588 – Elementary Partial Differential Equations II, University of Minnesota
- Fall 2016: Math 5587 – Elementary Partial Differential Equations I, University of Minnesota
- Spring 2016: Math 222B – Graduate Partial Differential Equations, UC Berkeley
- Fall 2015: Math 222A – Graduate Partial Differential Equations, UC Berkeley
- Fall 2015: Math 126 – Partial Differential Equations, UC Berkeley
- Spring 2015: Math 185 – Complex Analysis, UC Berkeley
- Fall 2014: Math 104 – Real Analysis, UC Berkeley

Summer schools and tutorials

- Co-organizer (with Jasmine Foo) in summer 2023 of an NSF-funded summer school and research program for high school students from underrepresented groups in mathematics. The research program focused on an introduction to deep learning and mathematical modeling of the spread of infectious diseases, and involved projects focused on using neural networks to predict Covid-19 infection rates.
- Organizer and instructor for ⟨run⟩:\the\world Machine Learning Virtual Summer Camp, a machine learning summer camp for high school students. The summer school has run every summer since 2020.
- Mini-course on *PDEs and Graph-Based Learning*, Summer School on Random Structures and Optimization in Related Applications, University of Minnesota, June 2021.
- Guest lecturer for course on *Mathematical Theory Behind Machine Learning*, Brigham Young University, March 2021.
- Tutorial on *Concentration of Measure with Applications to Graph-Based Learning*, IPAM program on High Dimensional Hamilton-Jacobi Equations, March 2020.
- Mini-course on *PDEs for Data Peeling*
  - Workshop on Stochastic PDEs, Mean Field Games and Biology, Gran Sasso Science Institute, L'Aquila, Italy, September 2017.
  - Workshop on Nonlinear Partial Differential Equations and the Calculus of Variations, UC Berkeley, May 2017.

Service

Conference organization

- Co-organized minisymposium *Geometric methods in machine learning and data analysis* with Leon Bungert at the International Congress on Industrial and Applied Mathematics, Tokyo, Japan, August, 2023.
- Co-organized minisymposium *Graph-Based Methods in Low-Label Rate Machine Learning* with Kevin Miller at the SIAM Conference on Mathematics of Data Science, September 2022.
- Organizer for the Fall 2020 IMA thematic semester *Harnessing the continuum for big data: Partial differential equations, calculus of variations, and machine learning.* Co-organizing two workshops:
  - Theory and algorithms in graph-based learning, Sept 14–18, 2020.
  - Optimal control, optimal transport, and data science, Nov 9–13, 2020.
- Co-organized IPAM workshop on *Stochastic analysis related to Hamilton-Jacobi PDEs*, May 18-22, 2020.
- Co-organized minisymposium *Partial Differential Equations in Machine Learning and Data Science* with Nadejda Drenska at the SIAM Conference on Analysis of PDE, December 2017.
- Co-organized minisymposium *Numerical Methods for PDE and Applications in Computational and Data Science* with Adam Oberman at the SIAM Conference on Analysis of PDE, December 2015.
- Co-organized minisymposium *Numerical Methods for Viscosity Solutions and Applications* with Adam Oberman at the SIAM Annual Meeting, Chicago, July 2014.

Editorial work

- Associate editor:
  - SIAM Review
  - SIAM Journal on Applied Mathematics
  - SIAM Journal on Numerical Analysis
- Co-editor for a special issue of the journal Research in Mathematical Sciences entitled *PDE methods for machine learning*, 2021–2022
- Manuscript reviewer for many journals, including
  Advances in Mathematical Physics, American Mathematical Monthly (AMM), Applied and Computational Harmonic Analysis (ACHA), Communications in Mathematical Sciences, Communications in Partial Differential Equations, ESAIM: Control, Optimisation and Calculus of Variations, European Journal of Applied Mathematics (EJAM), Foundations of Computer Science (FOCS) conference, IEEE Signal Processing Letters, Image Processing On Line (IPOL), IMA Journal of Numerical Analysis, Inverse Problems and Imaging (IPI), Linear Algebra and its Applications, Mathematics of Computation, Medical Image Analysis (MIA), Medical Image Computing and Computer Assisted Intervention (MICCAI) Conference, Neural Information Processing Systems (NIPS), Numerische Mathematik, Journal of the AMS, Journal of Computational and Applied Mathematics (CAM), Journal of Differential Equations, Journal of Mathematical Imaging and Vision (JMIV), Journal of Machine Learning Research (JMLR), SIAM Journal on Applied Mathematics (SIAP), SIAM Journal on Imaging Sciences (SIIMS), SIAM Journal on Multiscale Modeling and Simulation (MMS), SIAM Journal on Mathematical Analysis (SIMA), SIAM Journal on Mathematics of Data Science (SIMODS), SIAM Journal on Numerical Analysis (SINUM), SIAM Journal on Scientific Computing (SISC), SMAI Journal of Computational Mathematics, SIAM Books, Transactions of the AMS

University of Minnesota

- Co-organizer of IMA Data Science Seminar with Jasmine Foo, Will Leeb, Gilad Lerman, Yulong Lu, and Li Wang (2018–present)
- Committee Work
  - 2023–2024, Undergraduate Curriculum Committee, Diversity Commitee
  - 2022–2023, Faculty Search Commitee
  - 2021–2022, Faculty Search Commitee
  - 2020–2021, Graduate Studies Commitee, Climate Commitee
  - 2019–2020, Computer Commitee
  - 2018–2019, Computer Commitee, Dunham Jackson Postdoc Search Commitee
  - 2017–2018, Computer Commitee, Undergraduate Curriculum Commitee
  - 2016–2017, Computer Commitee

Memberships and other service

- NSF Proposal Reviewer, 2020, 2022, 2023
- Math Alliance Mentor since 2021.
- Member of the Society for Industrial and Applied Mathematics (2010–present), American Mathematical Society (2011–present), and the Sigma Xi Scientific Research Honor Society (2021–present).