Matthew J. Hirn

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Research Interests

high dimensional data analysis; harmonic analysis; data science; machine learning

- Mathematical foundations of deep learning: convolutional neural networks, neural networks on graphs and manifolds, generative models
- Geometric and graphical models for high dimensional data analysis: manifold learning, spectral graph theory, topological data analysis on graphs, graph and node embedding, biomedical data applications
- Machine learning and multiscale physics: physics based machine learning models, quantum chemistry, materials science, turbulence
- Inverse problems: multi-reference alignment
- Smooth extension and interpolation of data: Whitney-type extensions, Lipschitz extensions, efficient algorithms, statistical learning theory for regression

Positions Held

- *Associate Professor* 2020 – Present
  Assistant Professor 2015 – 2020
  Michigan State University
  Department of Computational Mathematics, Science & Engineering
  Department of Mathematics
  Center for Quantum Computing, Science & Engineering
- *Postdoctoral Researcher* 2013 – 2015
  École normale supérieure
  Department of Computer Science
  Mentor: Stéphane Mallat
- *Postdoctoral Associate* 2009 – 2013
  Yale University
  Department of Mathematics, Program in Applied Mathematics
  Mentor: Ronald R. Coifman

Education

- *PhD in mathematics*, University of Maryland, College Park 2004 – 2009
  Advisors: John J. Benedetto, Kasso Okoudjou
- *BA in mathematics*, Cornell University 2000 – 2004
  Advisor: Robert Strichartz

Awards & Honors

Total number of awards: 6 · Awards at MSU: 5 · Early career awards (highly competitive): 5

Some of these awards come with financial support; these monetary details are listed in the following section on Grants & Funding.

- NSF CAREER 2019
  15% award rate across across all of mathematics
- DARPA Director's Fellowship 2018
  7 awarded from the 27 Young Faculty Awards
- Kavli Fellow 2017
  Awarded by the National Academy of Sciences
- Alfred P. Sloan Fellowship in Mathematics 2016
  20 awarded across all of mathematics
- DARPA Young Faculty Award 2016
  27 awarded across applied science and engineering
- Ann G. Wylie Dissertation Fellowship 2009
  Awarded by the University of Maryland

Grants & Funding

Total number of grants: 7 · Grants awarded at MSU: 6 · Total funding awarded at MSU: $2,981,172 · Personal share of MSU funding: $2,003,784

- NIH #R01GM135929 2019 – 2023
  Matthew Hirn (PI), Smita Krishnaswamy (Yale, co-PI), Guy Wolf (Montreal, co-PI)
  $1,440,100 total / $582,712 personal share
  My role: Project leader and PI; MSU is the lead institution; sub-awards to Yale and Montreal
- NSF #1912906 2019 – 2021
  Anna Little (PI), Matthew Hirn (co-PI), Yuying Xie (co-PI)
  $150,000 total / $30,000 personal share
  My role: I contributed 20% to the proposal
- NSF #1845856 (CAREER) 2019–2024
  $400,000
  My role: Single PI
- DARPA #D16AP00117 (Young Faculty Award + Director's Fellowship) 2016 – 2020
  $744,297
  My role: Single PI
- Sloan Foundation #FG-2016-6607 (Alfred P. Sloan Fellowship) 2016 – 2020
  $55,000
  My role: Single PI
- NSF #1620216 2016 – 2020
  $191,775
  My role: Single PI

- AMS-Simons Travel Grant 2012 – 2015
  $4,000
  My role: Single PI

Advising

*I am the scientific leader of the **Compl**Ex **D**ata **A**nalysis **R**esearch (CEDAR) team at MSU, which currently has 11 members (the 2 postdocs and 9 graduate students listed below). The team has 2 alumni (1 postdoc and 1 graduate student).*

Postdoctoral Advising

Current

- Anna Little, CMSE 2017 – Present
  Co-mentored with Prof. Yuying Xie
  Will start a tenure track position at the University of Utah on January 1, 2021
- Paul Sinz, CMSE 2017 – Present

Alumni

- Michael Perlmutter, CMSE 2017 – 2020
  Co-mentored with Prof. Mark Iwen
  Now a fixed term Assistant Professor at UCLA

Graduate Advising

Current

- Nathan Brugnone, 5th year, Community Sustainability/CMSE 2017 – Present
  Co-advised with Prof. Robert Richardson
- Xavier Brumwell, 5th year, CMSE 2016 – Present
  Summer internship at Kirtland Air Force Research Lab (2019)
  Fully funded participant in the IPAM long program on *Machine Learning for Physics and the Physics of Learning* (2019)
- Albert Chua, 3rd year, Mathematics 2020 – Present
- Jieqian He, 5th year, CMSE/Statistics 2016 – Present
  Summer internship at Facebook (2020)
- Ryan LaRose, 4rd year, CMSE/Physics 2017 – Present
  MSU Engineering Distinguished Scholar (2017 – 2018)
  Summer internship at Los Alamos National Laboratory (2018)
  Summer internship at IBM (2019)
  Fall internship at NASA (2019)
  Spring internship at Google X (2020)
  Fitch H. Beach Award for Outstanding Doctoral Research (2020)
  NASA Space Technologies Graduate Research Opportunities Fellowship (2020 – 2023)

- Renming Liu, 2nd year, CMSE 2019 – Present
  Co-advised with Prof. Arjun Krishnan
- Sarah McGuire, 2nd year, CMSE 2019 – Present
  Co-advised with Prof. Elizabeth Munch
  MSU Engineering Distinguished Scholar (2019 – 2020)
- Liping Yin, 3rd year, Mathematics 2020 – Present
- Xitong Zhang, 1st year, CMSE 2020 – Present

Alumni

- Feng Gao, Dual PhD in Plant, Soil & Microbial Sciences and CMSE 2016 – 2019
  Advisor: Prof. Stephen Boyd
  I mentored Feng extensively on machine learning, and was on his PhD committee. He was an active member of the CEDAR team and had a permanent desk with my group.
  Currently a postdoc at Yale University working in the lab of Prof. Smita Krishnaswamy.

Undergraduate Advising

All undergraduate advising has been through NSF funded Research Experiences for Undergraduates (REUs). They are described below.

2018 REU project co-leader on "Machine Learning from Quantum Computing," which was part of the MSU ACRES REU. I co-mentored two students with Prof. Yue Qi of the ChEMS department:

- Muawiz Chaudhary (undergraduate at WWU)
- Nikhil Shankar (undergraduate at UM, Ann Arbor)

2013 REU project leader on "High Dimensional Data Analysis," which was part of the Cornell University Mathematics Department REU. I mentored six students:

- Ariel Herbert-Voss (went on to graduate school at Harvard for computer science)
- Nicholas Marshall (went on to graduate school at Yale for applied mathematics)
- Frederick McCollum (went on to be an NSF graduate fellow at NYU for financial math)
- Christian Smith (went on to graduate school at UW, Madison for sociology)
- Keyi Wu: (went on to be a software engineer at Bloomberg LP)
- Wendy Zeng: (went on to graduate school at UCSD for economics)

Short Term Visits

- *Senior Fellow*, Institute for Pure and Applied Mathematics (IPAM) 2016 (fall)
  For the program on "Understanding Many-Particle Systems with Machine Learning"
- *Visiting Assistant Professor*, Cornell University 2013 (summer)
  Department of Mathematics
  Directed NSF REU project on "High Dimensional Data Analysis"
- *Scientific Researcher*, Fields Institute 2012 (two weeks)
  For the "Focus Program on Whitney Problems"

- *Visiting Researcher*, Institute of Research of Mathematics of Rennes 2011 (three weeks)
  For research collaboration

PAPERS

Authors are listed in alphabetical order and are equal contributors (per the convention in Mathematics), unless otherwise noted as: John Smith (first author); Jane Doe† (principal investigator).*

Total number of papers: 32 · Reviewed and published research papers: 22 (19 in journals/conferences, 3 in workshops) · Invited, published conference papers (not reviewed): 2 · Published expository magazine articles: 1 · Submitted preprint articles for publication: 4 · Publicly available technical research reports that are not reviewed nor published: 4

Total citations: 510 · h-index: 13 · i10-index: 15 (from Google Scholar, September 14, 2020)

Associated codes and software packages: 8 (each is listed with the relevant paper(s)).

PEER REVIEWED JOURNAL AND CONFERENCE PAPERS

All papers in this list are rigorously peer reviewed.

19. Matthew Hirn and Anna Little.
    Wavelet invariants for statistically robust multi-reference alignment.
    Information and Inference: A Journal of the IMA, in press, 2020.
    Code: `wavelet-invariants`
18. Paul Sinz*, Michael Swift*, Xavier Brumwell, Jialin Liu, Kwang Jin Kim, Yue Qi†, Matthew Hirn†.
    Wavelet Scattering Networks for Atomistic Systems with Extrapolation of Material Properties.
    The Journal of Chemical Physics, volume 153, issue 8, 084109 (15 pages), 2020.
17. Michael Perlmutter*, Feng Gao, Guy Wolf and Matthew Hirn†.
    Geometric scattering networks on compact Riemannian manifolds.
    Proceedings of The First Mathematical and Scientific Machine Learning Conference, Proceedings of Machine Learning Research, volume 107, pages 570–604, 2020.
16. Mathieu Andreux, Tomás Angles, Georgios Exarchakis, Roberto Leonarduzzi, Gasper Rochette, Louis Thiry, John Zarka, Stéphane Mallat, Joakim Andén, Eugene Belilovsky, Joan Bruna, Vincent Lostanlen, Muawiz Chaudhary, Matthew J. Hirn, Edouard Oyallon, Sixhin Zhang, Carmine Cella and Michael Eickenberg.
    Kymatio: Scattering Transforms in Python.
    Journal of Machine Learning Research, volume 21, number 60, pages 1–6, 2020.
    Code: `Kymatio`.
15. Nathan Brugnone*, Alex Gonopolskiy*, Mark Moyle, Manik Kuchroo, David van Dijk, Kevin R. Moon, Daniel Colon-Ramos, Guy Wolf†, Matthew Hirn† and Smita Krishnaswamy†.
    Coarse Graining of Data via Inhomogeneous Diffusion Condensation.
    In *Proceedings of the 2019 IEEE International Conference on Big Data*, pages 2624–2633, 2019.
    Code: `condensation`.
14. Kevin R. Moon*, David van Dijk*, Zheng Wang*, Scott Gigante*, Daniel Burkhardt, William Chen, Kristina Yim, Antonia van den Elzen, Matthew J Hirn, Ronald R Coifman, Natalia B

Ivanova, Guy Wolf[†] and Smita Krishnaswamy[†].
Visualizing Structure and Transitions for Biological Data Exploration.
Nature Biotechnology, volume 37, pages 1482-1492, 2019.
Code: `PHATE`.

13. Feng Gao[*], Guy Wolf and Matthew Hirn[†].
Geometric Scattering for Graph Data Analysis.
Proceedings of the 36th International Conference on Machine Learning, PMLR, volume 97, pages 2122–2131, 2019.
Code: `geo-scattering-graph-data`.

12. Nicholas F. Marshall[*] and Matthew J. Hirn[†].
Time-coupled diffusion maps.
Applied and Computational Harmonic Analysis, volume 45, number 3, pages 709–728, 2018.

11. Michael Eickenberg, Georgios Exarchakis, Matthew Hirn, Stéphane Mallat and Louis Thiry.
Solid Harmonic Wavelet Scattering for Predictions of Molecule Properties.
The Journal of Chemical Physics, volume 148, issue 24, 241732 (9 pages), 2018.
Editor's pick.
Code: `Kymatio`.

10. Michael Eickenberg, Georgios Exarchakis, Matthew Hirn and Stéphane Mallat.
Solid Harmonic Wavelet Scattering: Predicting Quantum Molecular Energy from Invariant Descriptors of 3D Electronic Densities.
Advances in Neural Information Processing Systems 30, pages 6540–6549, 2017.
Code: `Kymatio`.

9. Matthew J. Hirn, Stéphane Mallat, and Nicolas Poilvert.
Wavelet scattering regression of quantum chemical energies.
Multiscale Modeling and Simulation, volume 15, number 2, pages 827–863, 2017.
Code: `ScatNet-QM-2D`.

8. Ariel Herbert-Voss, Matthew J. Hirn, and Frederick McCollum.
Computing minimal interpolants in $C^{1,1}(\mathbb{R}^d)$.
Revista Matemática Iberoamericana, volume 33, number 1, pages 29–66, 2017.
Code: `C-1-1-Interpolation`.

7. Matthew J. Hirn and Erwan Le Gruyer.
A general theorem of existence of quasi absolutely minimal Lipschitz extensions.
Mathematische Annalen, volume 359, number 3-4, pages 595–628, 2014.

6. Ronald R. Coifman and Matthew J. Hirn.
Diffusion maps for changing data.
Applied and Computational Harmonic Analysis, volume 36, number 1, pages 79–107, 2014.
Code: `Diffusion Maps for Changing Data`.

5. Ronald R. Coifman and Matthew J. Hirn.
Bi-stochastic kernels via asymmetric affinity functions.
Applied and Computational Harmonic Analysis, volume 35, number 1, pages 177–180, 2013.

4. Martin Ehler and Matthew J. Hirn.
Sparse endmember extraction and demixing.
In *Proceedings of the IEEE 2012 International Geoscience and Remote Sensing Symposium*, pages 1385–1388, Munich, Germany, July 22–27, 2012.

3. Matthew J. Hirn.
The number of harmonic frames of prime order.
Linear Algebra and Its Applications, volume 432, number 5, pages 1105–1125, 2010.

2. John J. Benedetto, Wojciech Czaja, Justin C. Flake and Matthew J. Hirn.
Frame based kernel methods for automatic classification in hyperspectral data.
In *Proceedings of the IEEE 2009 International Geoscience and Remote Sensing Symposium*, volume 4, pages 697–700, Cape Town, South Africa, July 12–17, 2009.

1. Matthew J. Hirn.
The refinability of step functions.
Proceedings of the American Mathematical Society, volume 136, number 3, pages 899–908, 2008.

Peer Reviewed Workshop Papers

All papers in this list are peer reviewed, but mostly for fit to the conference or workshop. Papers [2,3] received competitive recognition.

3. Xavier Brumwell*, Paul Sinz*, Kwang Jin Kim, Yue Qi and Matthew Hirn†.
Steerable Wavelet Scattering for 3D Atomic Systems with Application to Li-Si Energy Prediction.
In *NeurIPS Workshop on Machine Learning for Molecules and Materials*, 10 pages, 2018.
Contributed spotlight talk (only 9 out of 49 papers received a spotlight talk).

2. Michael Perlmutter*, Guy Wolf and Matthew Hirn†.
Geometric Scattering on Manifolds.
Extended abstract in *NeurIPS Workshop on Integration of Deep Learning Theories*, 5 pages, 2018.
Contributed spotlight talk (only 3 out of 40 papers receive a spotlight talk).
Longer version available on arXiv.

1. Tobias Welp*, Guy Wolf, Matthew Hirn and Smita Krishnaswamy†.
A Diffusion-based Condensation Process for Multiscale Analysis of Single Cell Data.
In *ICML Workshop on Computational Biology*, 5 pages, New York, June 24, 2016.

Invited Conference Papers

These are invited, published research papers that are not reviewed.

2. Feng Gao, Matthew Hirn, Michael Perlmutter and Guy Wolf.
Geometric wavelet scattering on graphs and manifolds.
In *Proceedings of SPIE 11138, Wavelets and Sparsity XVIII*, San Diego, California, August 2019.

1. John J. Benedetto, Wojciech Czaja, Martin Ehler, Justin C. Flake and Matthew J. Hirn.
Wavelet packets for multi and hyperspectral imagery.
In *Proceedings of IS&T/SPIE Electronic Imaging 2010, Wavelet Applications in Industrial Processing VII*, San Jose, California, January 2010.

Expository Papers

These are invited expository articles in magazine style publications.

1. Matthew J. Hirn.
Distinguished lecture series: Assaf Naor on the Lipschitz extension problem.
Fields Notes, volume 12, number 3, page 14, Winter 2013.

PREPRINTS

3. Michael Perlmutter*, Feng Gao, Guy Wolf and Matthew Hirn†.
Understanding Graph Neural Networks with Asymmetric Geometric Scattering Transforms.
Available on arXiv.

2. Michael Perlmutter*, Jieqian He and Matthew Hirn†.
Scattering Statistics of Generalized Spatial Poisson Point Processes.
Submitted, 2019.
Available on arXiv.

1. Adam Gustafson, Matthew Hirn, Kitty Mohammed, Hariharan Narayanan and Jason Xu.
Structural Risk Minimization for $C^{1,1}(\mathbb{R}^d)$ Regression.
Submitted, 2018.
Available on arXiv.

UNPUBLISHED PAPERS AND TECHNICAL REPORTS

4. A. Tkatchenko*, M. Afzal, C. Anderson, T. Baker, R. Banisch, S. Chiama, C. Draxl, M. Haghighatlari, F. Heidar-Zadeh, M. Hirn, J. Hoja, O. Isayev, R. Kondor, L. Li, Y. Li, G. Martyna, M. Meila, K.S. Ruiz, M. Rupp, H. Sauceda, A. Shapeev, M. Stöhr, K. R. Müller†, S. Shankar†.
IPAM Program on Machine Learning & Many-Particle Systems - Recent Progress and Open Problems.
Report for the Institute for Pure and Applied Mathematics (IPAM), 2017.

3. Matthew J. Hirn*, Nicolas Poilvert, and Stéphane Mallat†.
Quantum Energy Regression using Scattering Transforms.
arXiv:1502.02077, 2015.

2. Matthew J. Hirn.
Algorithms for computing the optimal Lipschitz constant of interpolants with Lipschitz derivative.
arXiv:1307.3292, 2013.

1. Matthew J. Hirn and David Widemann.
Frames for subspaces of $\mathbb{C}^n$.
arXiv:1410.5206, 2007.

INVITED TALKS

Total number of talks: 59 · Conference/workshop talks: 32 (4 particularly notable ones, see below) · Seminar talks: 27 (5 colloquia)

CONFERENCE AND WORKSHOP TALKS

Particularly notable conference talks have a footnote explaining their significance.

32. SPIE Wavelets and Sparsity XVIII.
Session on Applications of Frames and Transforms in Neural Networks.
San Diego, California.

Geometric wavelet scattering transforms on graphs and manifolds.
August 14, 2019

31. Fitting Smooth Functions to Data.[1]
University of Texas at Austin.
Fitting $C^{1,1}(\mathbb{R}^n)$ Functions to Data
August 8, 2019

30. International Congress on Industrial and Applied Mathematics.
Mini-symposium on Molecular simulation: dynamics, statistics, learning, and high performance computing.
Universitat de València.
Statistically Robust Multi-Reference Alignment with Wavelet Invariants.
July 16, 2019

29. International Congress on Industrial and Applied Mathematics.
Mini-symposium on Machine Learning for Materials.
Universitat de València.
Learning Material Properties with Multiscale Wavelet Scattering Transforms.
July 15, 2019

28. Third International Conference on Mathematics of Data Science.
City University of Hong Kong.
Learning on graphs and manifolds with geometric wavelet scattering transforms.
June 22, 2019

27. Understanding Many-Particle Systems with Machine Learning 2nd Reunion.
Institute for Pure and Applied Mathematics, UCLA.
Learning with Wavelet Scattering Transforms: Recent Results and Future Directions.
June 12, 2019

26. Scientific Computing Across Scales: Quantum Systems in Cold-matter Physics and Chemistry.
Fields Institute, University of Toronto.
Multiscale Machine Learning for Quantum Many Particle Physics with Wavelet Scattering Transforms.
April 23, 2019

25. AMS Fall Central Sectional Meeting.
Special Session on Extensions-Interpolation-Shape Matching in $\mathbb{R}^d$, Symmetry-Invariance, Algorithms and Related Topics.
University of Michigan.
Fitting Smooth Functions to High Dimensional Data.
October 21, 2018

24. Understanding Many-Particle Systems with Machine Learning 1st Reunion.
Institute for Pure and Applied Mathematics, UCLA.
Solid Harmonic Wavelet Scattering for Prediction of Molecular Properties.
June 14, 2018

[1] This five day conference consisted of ten lectures by Fields Medalist Charles Fefferman, in addition to five invited lectures on complementary topics delivered by leading experts in the field. I delivered one of the five invited lectures on a complementary topic.

23. Understanding Many-Particle Systems with Machine Learning 1st Reunion.[2]
Institute for Pure and Applied Mathematics, UCLA.
Introduction to Understanding Many-Particle Systems with Machine Learning.
June 11, 2018

22. 7th International Conference on Computational Harmonic Analysis.
Vanderbilt University.
Multiscale machine learning for many particle physics with wavelet scattering transforms.
May 15, 2018

21. The Mathematics of Deep Learning.
Institute for Advanced Study, Hong Kong University of Science and Technology.
Three dimensional deep learning and many body physics.
January 8, 2018

20. Geometry and Topology of Data.
Institute for Computational and Experimental Research in Mathematics, Brown University.
Transferring diffusion based manifold learning to trajectories and time varying data.
December 11, 2017

19. Big Data driven Materials Science.
Centre Européen de Calcul Atomique et Moléculaire, EPFL.
Solid Harmonic Wavelet Scattering.
September 11, 2017

18. The 9th Applied Inverse Problems Conference.
Session on Inverse Problems and Low Complexity Models.
Zhejiang University.
Deep Wavelet Scattering: Towards Mathematical Understanding of Convolutional Networks through Physics, Probability and Manifolds.
June 1, 2017

17. First International Conference on Mathematics of Data Science.
Hong Kong Baptist University.
Learning Many Body Physics with Multiscale, Multilayer Machine Learning Architectures.
March 20, 2017

16. Understanding Many-Particle Systems with Machine Learning Culminating Workshop.
Institute for Pure and Applied Mathematics, UCLA.
Scattering Transform Kernels.
December 13, 2016

15. Understanding Many-Particle Systems with Machine Learning Tutorials.
Institute for Pure and Applied Mathematics, UCLA.
Wavelet Tutorial, Part II.
September 14, 2016

14. Understanding Many-Particle Systems with Machine Learning Tutorials.
Institute for Pure and Applied Mathematics, UCLA.
Wavelet Tutorial, Part I.
September 13, 2016

[2]This was an evening lecture presented to the entire congregation at Lake Arrowhead, which consisted of researchers from three separate IPAM long programs.

13. Understanding Many-Particle Systems with Machine Learning Opening Day.[3]
Institute for Pure and Applied Mathematics, UCLA.
Multiscale Machine Learning.
September 12, 2016

12. The 11th American Institute of Mathematical Sciences (AIMS) Conference on Dynamical Systems, Differential Equations and Applications.
Special Session on Harmonic Analysis and Partial Differential Equations.
Orlando, Florida.
Deep Wavelet Scattering for Quantum Energy Regression.
July 1, 2016

11. American Physical Society March Meeting 2016.[4]
Session on Predicting and Classifying Materials via High-Throughput Databases and Machine Learning.
Baltimore, Maryland.
Deep Wavelet Scattering for Quantum Energy Regression.
March 15, 2016

10. 8th Whitney Problems Workshop.
CIRM, Luminy, France.
Computing Minimal Interpolants in $C^{1,1}(\mathbb{R}^d)$ (with A. Herbert-Voss and F. McCollum).
October 22, 2015

9. PASC15 Conference.
Minisymposium on Big Data Analytics for Novel Materials Discovery.
ETH Zürich.
Quantum Energy Regression by Scattering Transforms.
June 1, 2015

8. Foundations of Computational Mathematics Conference 2014.
Workshop A2: Computational Harmonic Analysis, Image and Signal Processing.
Universidad de la República.
High dimensional learning rather than computing in quantum chemistry.
December 12, 2014

7. 5th International Conference on Computational Harmonic Analysis.
Vanderbilt University.
Minimal $C^{1,1}$ *extensions.*
May 23, 2014

6. Statistics, Mathematics, and Applications.
Fréjus, France.
Diffusion maps for changing data.
September 3, 2013

5. Workshop on Whitney type extension and trace problems.
Fields Institute, University of Toronto.
A general theorem of existence of quasi absolutely minimal Lipschitz extensions.
August 28, 2012

[3]This lecture was one of four given during the opening day retreat, and was meant to set the stage for the semester long program on "Understanding Many-Particle Systems with Machine Learning."

[4]This was a 36 minute invited talk at the March APS meeting, which requires a nomination by the session organizers. It was the only invited talk for this session.

4. Operator Algebras, Frames, and Undergraduate Research: A Conference in Honor of the 70th Birthday of David R. Larson.
   Texas A&M University.
   Diffusion maps for changing data.
   July 21, 2012
3. Fourth Whitney Problems Workshop.
   College of William and Mary.
   Wells' construction of interpolants in $C^{1,1}(\mathbb{R}^n)$.
   August 4, 2011
2. Mini-Conference in Harmonic Analysis on the Occasion of John Benedetto's 70th Birthday.
   University of Maryland, College Park.
   Harmonic frames of prime order.
   August 21, 2009
1. Graduation Conference 2009.
   University of Maryland, College Park.
   Frame based kernel methods for hyperspectral imagery data.
   May 1, 2009

Seminar Talks

27. Pennsylvania State University.
    Computational and Applied Mathematics Colloquium.
    Multiscale invariant representations for learning on high dimensional data.
    March 2, 2020
26. Lawrence Berkeley National Lab.
    Multiscale Machine Learning for Quantum Many Particle Physics with Wavelet Scattering Transforms.
    January 6, 2020
25. University of Notre Dame.
    Statistics Seminar.
    Invariant Data Representations with Multiscale Mathematical Models for ConvNets.
    October 1, 2019
24. Michigan State University.
    NSCL/FRIB Nuclear Theory Seminar.
    Machine Learning for Quantum Many-Particle Physics.
    November 13, 2018
23. Michigan State University.
    ACRES REU Seminar Series.
    Computational Harmonic Analysis and Data Science.
    June 6, 2018
22. RWTH-Aachen University.
    Center for Computational Engineering Science Seminar.
    Multiscale Machine Learning and Many Body Physics.
    September 18, 2017

21. Shanghai Jiao Tong University.
Applied Math Seminar.
Multiscale Machine Learning and Many Body Physics.
June 6, 2017

20. Johns Hopkins University.
Data Analysis Seminar.
Learning Many Body Physics with Multiscale, Multilayer Machine Learning Architectures.
March 8, 2017

19. Michigan State University.
Physical Chemistry Seminar.
High Dimensional Learning Rather than Computing in Quantum Chemistry.
November 17, 2015

18. Michigan State University.
Computer Science and Engineering Lecture Series.
High Dimensional Learning Rather than Computing in Quantum Chemistry.
October 9, 2015

17. Michigan State University.
Applied Math Seminar.
Quantum Energy Regression by Scattering Transforms.
September 11, 2015

16. University of Minnesota.
Mathematics Colloquium.
Interpolation for Physical Big Data.
February 26, 2015

15. City College of New York.
Mathematics Colloquium.
Interpolation for Physical Big Data.
February 18, 2015

14. Yale University.
Applied Mathematics Seminar.
High Dimensional Learning rather than Computing in Quantum Chemistry.
February 4, 2015

13. Michigan State University.
Mathematics Colloquium.
Interpolation for Physical Big Data.
January 16, 2015

12. Institut Henri Poincaré.
Analyse non-linéaire et EDP seminar.
Minimal $C^{1,1}$ Extensions.
April 15, 2014

11. École normale supérieure.
Sierra group meeting.
Diffusion based manifold learning (joint talk with Guy Wolf).
October 23, 2013

10. Cornell University.
    REU Smorgasbord Seminar.
    Diffusion geometry for high dimensional data.
    July 3, 2013
9. Yale University.
    Analysis Seminar.
    Quasi absolutely minimal Lipschitz extensions.
    February 21, 2013
8. Cornell University.
    Analysis Seminar.
    New developments in the theory of absolutely minimal Lipschitz extensions.
    December 3, 2012
7. Kansas State University.
    Mathematics Colloquium.
    Diffusion maps for changing data.
    November 29, 2012
6. University of Houston.
    Image Analysis Seminar.
    Diffusion maps for changing data.
    November 5, 2012
5. Vanderbilt University.
    Computational Analysis Seminar.
    Diffusion maps for changing data.
    October 17, 2012
4. University of Maryland.
    Norbert Wiener Center Seminar.
    Diffusion maps for changing data.
    October 2, 2012
3. Bell Labs.
    Mathematics Colloquium and Informal Seminar.
    Diffusion maps for changing data.
    July 26, 2012
2. Duke University.
    Applied Mathematics Seminar.
    Diffusion maps for changing data.
    January 23, 2012
1. École Normale Supérieure de Cachan, Antenne de Bretagne, France.
    Groupe de travail "applications des mathématiques,"
    Minimal interpolants in $C^{1,1}(\mathbb{R}^n)$.
    December 7, 2011

TEACHING

Number of distinct courses taught: 7 · Distinct courses taught at MSU: 5 · Courses developed: 3

MICHIGAN STATE UNIVERSITY

- CMSE 890: Mathematics of Deep Learning.
  Topics level graduate course that I developed.
  Spring 2020
- MATH 994: Applied and Computational Harmonic Analysis.
  Topics level graduate course that I developed.
  Spring 2018, Spring 2020
- CMSE 820: Mathematical Foundations of Data Science.
  New qualifying exam course for the Department of Computational Mathematics, Science & Engineering (CMSE), which I developed. In addition to teaching the course, I wrote two qualifying exams associated with it and organized weekly summer review sessions.
  Spring 2017
- CMSE 201: Introduction to Computational Modeling.
  Flipped class. Spring 2016 was the first time the course ran.
  Spring 2016, Fall 2018
- MATH 414: Linear Algebra II.
  Fall 2015

YALE UNIVERSITY

- MATH/AMTH 244: Discrete Mathematics.
  Fall 2009, Fall 2010

UNIVERSITY OF MARYLAND

- Review Course for Analysis PhD Qualifying Exam.
  Summer 2007
- Math 111: Introduction to Probability.
  Fall 2005, Spring 2006

SERVICE

EDITORSHIP

- Member of the Editorial Board for *Sampling Theory, Signal Processing, and Data Analysis*.
  2020 – Present
- Editor for the book, *Excursions in Harmonic Analysis, Volume 6 - In Honor of John Benedettos 80th Birthday*.

CONFERENCE AND SEMINAR ORGANIZATION

- Co-organizer of the the virtual mini-symposium on "Multiscale Data Science Inspired by Biological and Physical System" (part II here), which was part of the SIAM Annual Meeting.
  July 14 and 15, 2020
- Co-organizer of the virtual mini-symposium on "Deep thoughts on geometric learning & exploration of non-Euclidean data", which was part of the SIAM Conference on Mathematics

of Data Science Conference.
June 17 and 24, 2020

- Co-organizer of the "One World Mathematics of INformation, Data, and Signals (MINDS) Seminar,", which is an online seminar developed in response to the COVID-19 pandemic. Over 1000 people on the mailing list, and consistently over 100 attendees each week.
Summer and Fall, 2020
- Co-organizer of the summer school on "Machine Learning Applied to Nuclear Physics."
Held at the Facility for Rare Isotope Beams, Michigan State University.
Personally delivered 3 lectures on *Unsupervised Learning and Exploratory Data Analysis*.
Approximately 100 people in attendance.
May 2019
- Organized mini-session on "Kernel Learning and Harmonic Analysis."
Held during the "Culminating Workshop of the IPAM long program on Understanding Many-Particle Systems with Machine Learning."
December 2016
- Co-organizer of the "8$^{\text{th}}$ Whitney Problems Workshop 2015."
Held at the Centre International de Rencontres Mathématiques (CIRM).
October 2015
- Applied Mathematics Seminar co-organizer.
Yale University.
2012 – 2013
- Norbert Wiener Center Seminar co-organizer.
University of Maryland.
2007 – 2008

Grant Evaluation

- NSF computational mathematics panel member: 2020
- Reviewer for DOE grant proposals: 2017
- Joint NSF/NIH panel member: 2016

Journal and Conference Reviewer

- Applied and Computational Harmonic Analysis: 2011 – 2020 (top 10% reviewer)
- European Journal of Operational Research: 2018 – 2019
- IEEE Signal Processing Letters: 2013 – 2014
- IEEE Transactions on Circuits and Systems for Video Technology: 2018
- IEEE Transactions on Information Theory: 2012
- International Conference on Machine Learning (ICML): 2019 (top 5% reviewer)
- International Journal of Quantum Chemistry: 2018
- Linear Algebra and Its Applications: 2009
- Neural Computation: 2013
- Neural Information Processing Systems (NeurIPS): 2019 (top 50% reviewer), 2020

- NPJ Computational Materials: 2017
- Proceedings of the American Mathematical Society: 2011
- SIAM Journal on Applied Dynamical Systems: 2013
- Signal Processing: 2014

UNIVERSITY COMMITTEES

- Chair of the CMSE Undergraduate Studies Committee
  During this period the Departments of CMSE, Computer Science, and Statistics developed a new undergraduate degree in *Data Science*. As chair of the committee, I am also a member of the College of Natural Science Undergraduate Chairs and Directors Meetings and the College of Engineering Undergraduate Studies Committee.
  2017 – 2020 (three years)
- CMSE Long Term Steering Committee
  2017 – 2018
- CMSE/CSE/ECE Hiring Committee
  Connected and autonomous networked vehicles for active safety (CANVAS). Resulted in the hiring of Shaunak D. Bopardikar (ECE) and Bahare Kiumarsi (ECE).
  2017 – 2018
- CMSE/CSE/BME/ECE Hiring Committee
  Machine learning and deep learning
  2017 – 2020 (three year search)
- Mathematics/CMSE Hiring Committee
  Fixed term to tenure stream conversion. Resulted in the conversion of Ekaterina A. Rapinchuk (Math/CMSE) from fixed term to tenure track.
  2017 – 2018
- CMSE/ChEMS Hiring Committee
  Computational materials science. Resulted in the hiring of Hui-Chia Yu (CMSE/ChEMS).
  2016 – 2017

UNIVERSITY OUTREACH

- Panel member for the "NSF CAREER coffee break"
  University wide panel providing tips for apply for the NSF CAREER award
  February 20, 2020
- Panel member on "Getting Started at MSU"
  University wide new faculty orientation at Michigan State University
  August 23, 2018
- CMSE Department promotional talk
  Shanghai Jiao Tong University
  June 6, 2017
- CMSE Department promotional talk
  Fudan University
  June 5, 2017

- Panel member on "Getting Grants"
  Michigan State University, College of Natural Science.
  September 9, 2016
- Panel member on "How to look for an academic job"
  Michigan State University, Department of Mathematics.
  November 5, 2015
- Speaker at Putnam Exam review sessions
  Yale University
  Fall 2009