Mathew Hu

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Research Interests

- Optimization & uncertainty quantification in large-scale inverse problems
- Machine learning applications in scientific computing
- High-performance computing for simulation and modeling

Education

- B.S., Mathematics and Applied Mathematics, Department of Mathematical Sciences, Fudan University, Shanghai, China, 2017
- M.S., Mathematics, Courant Institute of Mathematical Sciencess, New York University, New York, New York, 2019 (Antoine Cerfon, advisor; Georg Stadler, co-advisor)
- Ph.D., Computational Science, Engineering, and Mathematics (CSEM), Oden Institute for Computational Engineering & Sciences, The University of Texas at Austin, Austin, Texas (Omar Ghattas, advisor; Rami Nammour, co-advisor) (expected Aug. 2025)

Relevant Courseworks

- Mathematics: Math Analysis, Complex Analysis, Functional Analysis, PDEs, Methods of Applied Math, Linear Algebra, Abstract Algebra, Topology, Differential Geometry, Probability, Statistics
- Computational Methods: Numerical Methods, Finite Element Methods, Inverse Problems, Predictive Computational Sciences, Fast Algorithms in Scientific Computing, Simulation, Optimization, Markov Chains
- Machine Learning: Machine Learning and Data Sciences, Scientific Computing in Machine & Deep Learning
- Appications: Mathematical Modeling, Physics, Mechanics, Seismology

Research Experience

- Graduate Research Assistant, Center for Optimization, Inversion, Machine Learning, and Uncertainty for Complex Systems (OPTIMUS), Oden Institute for Computational Engineering & Sciences, The University of Texas at Austin, 12/2019 – Present
  - Developed innovative preconditioning algorithms for seismic inversion, enhancing computational efficiency.
  - Improved large-scale optimization algorithms (L-BFGS and inexact Newton-CG) by integrating novel preconditioners, reducing computation time by 50% and greatly enhancing imaging fidelity.
  - Enhanced MCMC methods for UQ in seismic imaging within a Bayesian inference framework, generating 10x more effective samples and enabling more reliable data interpretation with deeper insights into subsurface structures.
  - Executed large-scale acoustic wavefield simulations on the Frontera supercomputer using HPC tools.
  - Developed and maintained Python and Julia codebases, ensuring robust and efficient computational tools.
- Research Geophysicist Intern, TotalEnergies E&P USA, Inc., 05/2023 - 08/2023
  - Developed explainable deep learning models to accelerate seismic inversion and seismic data processing.
  - Designed and implemented a neural network architecture in PyTorch to approximate the second derivative (Hessian) for seismic inversion, overcoming traditional challenges in approximating this complex operator.
  - Implemented large-scale preconditioned quasi-Newton methods, reducing seismic inversion time by 40%.
  - Performed acoustic waveform simulations using Julia and HPC tools on a Linux OS.
  - Collaborated with a multidisciplinary team to interpret computational results using geoscience knowledge.
  - Presented research findings to diverse audiences, clearly communicating complex concepts and fostering collaboration.
- Graduate Research Assistant, Magneto-Fluid Dynamics Division, Courant Institute of Mathematical Sciences, New York University, 02/2018 – 05/2019
  - Developed an efficient grid-based method in MATLAB to compute magnetic flux surfaces from discrete field data.
  - Theoretically demonstrated spectral convergence for integrable magnetic fields.

Publications

1. Mathew Hu, Nick Alger, Omar Ghattas, Rami Nammour, Fast approximations of high-rank Hessians: Applications to seismic inversion and uncertainty quantification (In Preparation)

Conference Presentations

1. Fast approximations of high-rank Hessians: Applications to seismic inversion and uncertainty quantification, *The International Meeting for Applied Geoscience & Energy (IMAGE)*. Houston, Texas, USA. Aug. 30, 2024.
2. Fast approximations of high-rank Hessians: Applications to seismic inversion and uncertainty quantification, *5th Annual Meeting of the SIAM Texas-Louisiana Section*. Houston, Texas. Nov 5, 2022.
3. Fast approximation of high-rank Hessians to accelerate MCMC for Bayesian seismic inversion, *SIAM Conference on Uncertainty Quantification*. Atlanta, Georgia. April 12, 2022.

Teaching Experience

Role	Course	Delivery Method	# of Sections	# of Students	Institute	Semester
GTA	Math for Economics II	In-Person	1	30	NYU	Spring 2019
GTA	Math for Economics I	In-Person	1	30	NYU	Fall 2018

Awards and Honors

1. O'Dennell Fellowship, Oden Institute for Computational Engineering & Sciences, 2019
2. Academic Professional Scholarship, Fudan University, 2016, 2015, 2014
3. Outstanding Student Scholarship, Fudan University, 2016, 2015, 2014
4. National Endeavor Fellowship, Fudan University, 2014
5. First Prize, National College Mathematics Contest (Shanghai Division), 2014, 2013
6. First Prize, Chinese Mathematical Olympiad in Senior (Top 40 in Zhejiang, population 54.6 million), 2011
7. First Prize, Chinese Southeast Mathematical Olympiad (Only Perfect Score), 2011
8. Second Prize, Chinese Mathematical Olympiad in Senior, 2010

Relevant Technology Skills

- Programming Languages: Python, Julia, MATLAB, R, SQL, C++
- Packages & Tools: FEniCS (FEM computing platform), hippylib (Inverse problem Python library), PyTorch, TensorFlow, Keras, AutoKeras, scikit-learn, SciPy
- Experience with HPC systems