Quan Guo, PhD

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Summary

I am a versatile researcher specializing in physics simulations and AI-driven analysis, with expertise in numerical modeling, machine learning, and inference. My work focuses on leveraging advanced **deep learning models** to address challenges in **spatio-temporal modeling** and **geophysical inference**, aiming to bridge the gap between computational methods and real-world applications. My research spans several key areas:

- **Scientific Machine Learning:** Educating machine learning with physical knowledge to solve PDEs efficiently: physics informed neural networks, neural operators, etc.
- **Bayesian Optimization & Inference:** Utilizing Bayesian and random fields to conduct dimensionality reduction and optimization for large-dimensional inverse problems.
- **Domain Generalization:** Creating AI generative models to encode multiple distributions, supporting uncertainty quantification with broader prior assumptions.
- **Digital Twin:** Employing imaging and computer vision computer vision techniques to render invisible physical systems based on sensory data.

Through my interdisciplinary expertise, I aim to advance the integration of AI and geophysics, driving innovation in subsurface exploration and digital simulation technologies.

Education

PhD in Civil Engineering, Georgia Institute of Technology, Atlanta, GA 2019 - 2024

- Dissertation: *Physics Informed Deep Learning Application in High-Dimensional Groundwater Inverse Modeling of Hydraulic Tomography*
- Adviser: Prof. Jian Luo

MS in Computer Engineering, Georgia Institute of Technology, Atlanta, GA 2017 - 2018

MS in Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 2016 - 2017

BS in Ecology, Xiamen University, Xiamen, Fujian, China 2012 - 2016

Research Funding

Principal Investigator, ISTI FY25 Rapid Response, Los Alamos National Laboratory 2025

Teaching

Hydraulic Engineering, CEE4200, Georgia Institute of Technology 2019, 2020

Big Data for Healthcare, CSE6250, Georgia Institute of Technology 2020 – 2024

Professional Experience

Postdoc, Los Alamos National Laboratory**,** Los Alamos, NM 2024 - Present

- Authored a highly competitive research proposal as Principal Investigator, securing funding with a 13% acceptance rate within six months of joining.

- Lead developer of *SimCCS*, an R&D 100 Award-winning software, enabling users to interactively simulate the diffusion of deformable plumes and assess well-drilling risks through integrated numerical and machine learning models.
- Collaborated with 50 scientists across 10+ institutions on the DOE SMART project to optimize ML-based history matching models, enhance software infrastructure and build demos to present tools to DOE sponsors.
- Published 3+ proceedings at top-tier conferences, including CCUS 2025 and GHGT-17.
- Delivered technical presentations to governmental sponsors and private-sector stakeholders, securing continued funding for cutting-edge research projects.

Research Assistant, Georgia Institute of Technology, Atlanta, GA 2019 – 2024

- Implemented Physics Informed Neural Networks (PINNs) for scalable inverse modeling and designed corresponding data fusion and training strategy, performing 10x faster on high-resolution PDE parameter estimation than the best numerical model.
- Created Fourier Neural Operator (FNO)-based surrogate models to enhance elliptic PDE solution performance, improving forward solution by 10x and backpropagation speed by 100x.
- Implemented GAN to encode non-linear random fields at low-dimensional space, enhancing computational efficiency by 50x for estimating the fields.
- Applied Bayesian optimization and random field analysis to reduce dimensionality in physical field variables by 99%, enabling efficient parameter estimation.
- Introduced upscaling methods to achieve up to 1000x faster Jacobian evaluations. Conducted error analysis on the numerical method and found the optimal upscaling rate for balance speed and accuracy.
- Published 5+ papers in leading journals, including *Water Resources Research* and *Journal of Hydrology*, contributing to machine and computational methods for geosciences.

Machine Learning Engineer, Schlumberger-Doll Research**,** Cambridge, MA 2023

- Reviewed cutting-edge AI methodologies and implemented generative AI for reservoir characterization, reducing analysis time from two days to five minutes.
- Built an ML infrastructure integrating Kubernetes, CUDA, Docker, and PyTorch on Azure DevOps, streamlining model training for geophysical applications and becoming the company's standard Python-based workflow.

Editorial Experience

Editor

- Guest Editor, *Hydrology* 2024 - Present

  Special Issue: Advancing Hydrological Science through Artificial Intelligence: Innovations and Applications

Reviewer

- Water Resources Research
- Journal of Hydrology
- ARMA
- SPE Journal
- Journal of Petroleum Science and Engineering

Collaborators and Co-Authors

- Jian Luo, Georgia Institute of Technology
- Minjae Kim, Georgia Institute of Technology
- Yu He, Sichuan University
- Chunhui Lu, Hohai University

- Bailian Chen, Los Alamos National Laboratory
- Martin Ma, Los Alamos National Laboratory
- Yue Zhao, Meta Platforms, Inc.
- Ming Liu, Meta Platforms, Inc.

Professional Affiliations

Member, AGU 2023 – 2024

Services and Volunteer

GUIDE Member, EES Division at Los Alamos National Laboratory 2024 – Present
DEI Association Member, CEE at Georgia Institute of Technology 2023 – 2024
President of Student Association, CEE at Xiamen University 2014 – 2015

Skills

Numerical: Numerical Linear Algebra, FEM Solver, Random Field Analysis, Bayesian Inference
Machine Learning: PINNs, Neural Operators, GANs, TensorFlow, PyTorch, Scikit-learn
Data Engineering: Python, SQL, Azure, AWS, Docker, Kubernetes, Spark, Hadoop
High-Performance Computing: CUDA, Parallel Computing Frameworks
Communication: Scientific Writing, Presentations, Teaching

Publications

Peer-reviewed journals

- Guo, Q., He, Y., Liu, M., Zhao, Y., Liu, Y., & Luo, J. (2024), Reduced Geostatistical Approach With a Fourier Neural Operator Surrogate Model for Inverse Modeling of Hydraulic Tomography, *Water Resour. Res.,* 60(6), e2023WR034939, doi: https://doi.org/10.1029/2023WR034939.
- Guo, Q., Liu, M., & Luo, J. (2023), Predictive Deep Learning for High-Dimensional Inverse Modeling of Hydraulic Tomography in Gaussian and Non-Gaussian Fields, *Water Resour. Res.*, 59(10), e2023WR035408, doi: https://doi.org/10.1029/2023WR035408.
- Guo, Q., Zhao, Y., Lu, C., & Luo, J. (2023). High-dimensional inverse modeling of hydraulic tomography by physics informed neural network (HT-PINN). *Journal of Hydrology*, 616, 128828, doi: https://doi.org/10.1016/j.jhydrol.2022.128828.
- Liu, Y., He, Y., Guo, Q., Kim, M., Rathore, S., & Luo, J. (2024), Impact of Boundary Conditions on Modeling Seawater Intrusion in Stratified Coastal Aquifers Under Sea Level Rise, doi: http://dx.doi.org/10.2139/ssrn.4912526.
- He, Y., Guo, Q., Liu, Y., Huang, H., Hou, D., & Luo, J. (2024). Multiphysics Modeling Investigation of Wellbore Storage Effect and Non-Darcy Flow. *Water Resources Research*, 60(1), e2023WR035453. doi: https://doi.org/10.1029/2023WR035453.
- Zhao, Y., Guo, Q., Lu, C., & Luo, J. (2022). High-dimensional groundwater flow inverse modeling by upscaled effective model on principal components. *Water Resour. Res.*, 58(7), e2022WR032610. doi: https://doi.org/10.1029/2022WR032610.

Conference Proceedings

- Chen, B., Ma, Z., Ahmmed, B., Guo, Q., Li, W., Mehana, M., Meng, M., & Pawar, R. (2024), Unified SimCCS Platform for Decision-Making in Carbon Capture, Transport, and Storage Infrastructure, paper presented at Proceedings of the 17th Greenhouse Gas Control Technologies Conference (GHGT-17), 20-24 October 2024, doi: http://dx.doi.org/10.2139/ssrn.5030859.
- Ma, Z., Guo, Q., Viswanathan, H., Pawar, R., & Chen, B. (2024), Deep Learning Assisted History Matching and Forecasting: Applied to the Illinois Basin – Decatur Project (IBDP), paper

presented at Proceedings of the 17th Greenhouse Gas Control Technologies Conference (GHGT-17), 20-24 October 2024, doi: http://dx.doi.org/10.2139/ssrn.5019810.

Conference and Workshop Presentations

- [Poster] Guo, Q., Ma, Z., & Chen, B. An Innovative Method to Evaluate Cost of CO_2 Shipping, In: CCUS 2025, Houston, TX, March 2025
- [Poster] Guo, Q., Ma, Z., & Chen, B. Unified SimCCS Platform for Decision-Making in Carbon Capture, Transport, and Storage, In: CESAM 2024, Socorro, NM, November 2024
- [Presentation] Guo, Q., Luo, J. Large-scale Inverse Modeling of Hydraulic Tomography by Physics Informed Neural Network, In: AGU 2022 Fall Meeting, Chicago, IL, December 2022

Invited Talks and Seminars

- Scalable high-dimensional inverse modeling of hydraulic tomography by physics informed neural network (HT-PINN). In: National Environmental Conference for Doctoral Students, Beijing, China, January 2023.
- Physics informed neural network in groundwater inverse modeling. In: Water Resource Engineering Seminar, Georgia Institute of Technology, Atlanta, GA, March 2022.