Zezheng Song
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Research Area

Scientific machine learning, deep learning, randomized linear algebra, high performance computating, and representation learning.

Education

- **University of Maryland** — College Park, MD
  Ph.D Candidate in Applied Mathematics; Advisor: Haizhao Yang — *Aug. 2019 – Expected May. 2025*
  - **GPA**: 3.80/4.0;
  - **Core Curriculum**: Numerical Methods for Machine Learning, Numerical Optimization, Deep Learning, Stochastic Processes, Complex Analysis
- **University of Texas at Austin** — Austin, TX
  Mathematical Sciences, Bachelor of Science; Advisor: Kui Ren — *Aug. 2015 – Jun. 2019*

Internship

- **Lawrence Berkeley National Laboratory** — Berkeley, CA
  NSF Mathematical Sciences Graduate Intern. Mentor: Sherry Xiaoye Li — *Jun. 2022 – Aug. 2022*
- **National Institute of Health** — Baltimore, MD
  Research Assistant. Mentor: Richard G. Spencer — *Jun. 2020 - Aug. 2020*

Research Projects

- **Solving Committor Functions with Finite Expression Method** — Oct 2022 - Present
  Mentor: Haizhao Yang, Department of Mathematics, University of Maryland — *College Park, MD*
  - Utilized the Finite Expression Method (FEX), a deep reinforcement learning technique, to approximate solutions for partial differential equations in the space of functions with finitely many analytic expressions. Applied this method to successfully solve for committor functions in diverse scenarios, including the double-well potential and transition processes between pairs of co-centric spheres. Additionally, applied FEX to solve problems involving rugged-Muller potentials.
  - The analytic solutions obtained through FEX offer valuable insights into the underlying structure of the committor functions. Additionally, the resulting relative error achieved by FEX is remarkable, reaching machine accuracy and surpassing the current state-of-the-art neural network approach.
- **Acceleration of Kernel Methods with Nystrom Approximation** — Berkeley, CA
  Mentor: Sherry Xiaoye Li, Lawrence Berkeley National Laboratory — *Jun. 2022 - Aug. 2022*
  - Applied randomized sketching methods, including subsampled randomized Fourier transform (SRFT) and leverage score sampling, to expedite the performance of kernel-based machine learning algorithms.
  - Developed and proposed an innovative index selection method for the CUR matrix decomposition algorithm, utilizing a fast leverage score approximation of the data matrix. This method achieved superior performance on various datasets, outperforming the current state-of-the-art algorithm.
- **Parameter Estimation in Magnetic Resonance Relaxometry Model** — College Park, MD
  Mentor: Richard G. Spencer, National Institute of Health — *Jun. 2020 - Aug. 2020*
  - Utilized Matlab to implement and compare multiple state-of-the-art numerical optimization algorithms, including grid search, gradient descent, and the Levenberg-Marquardt method, for learning the parameters in the biexponential magnetic resonance relaxometry model.
  - Introduced regularization into the loss function of the bi-exponential magnetic resonance relaxometry model to reduce the mean squared error of estimators below the theoretical lower bound by 53.82%. This involved implementing state-of-the-art numerical optimization algorithms such as grid search, gradient descent, and the Levenberg-Marquardt method to efficiently learn the model parameters.

Publications

[1] R. Spencer, R. Neff, C. Bi, R. Balan, and Z. Song, "Breaking the crlb barrier: Decreasing mean squared error in parameter estimation through introduction of regularization bias," in *APS March Meeting Abstracts*, vol. 2022, 2022, Q29–005.

[2] Z. Song, M. K. Cameron, and H. Yang, "A finite expression method for solving high-dimensional committor problems," *arXiv preprint arXiv:2306.12268*, 2023.

Awards

- National Science Foundation Mathematical Sciences Graduate Fellowship, 2022.
- Dean's Fellowship, Department of Mathematics, University of Maryland, College Park, 2019-2021.
- Moncrief Undergraduate Summer Fellowship, Oden Institute for Computational Engineering and Sciences, 2018.

Presentations

- A Finite Expression Method for Solving High-Dimensional Committor Problems, CBMS Conference: Deep Learning and Numerical PDEs, Baltimore, June, 2023
- Solving High-Dimensional Committor Functions with Finite Expression Method (FEX), RIT on Machine Learning for Rare Events, University of Maryland, College Park, February 2023.
- Acceleration of Kernel Methods with Nystrom Approximation, National Science Foundation, Mathematical Sciences Summer Research Symposium, August, 2022

Programming Skills

- **Languages**: Python (PyTorch), Matlab, R, LaTeX