Shi Chen

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EDUCATION

Department of Mathematics, University of Wisconsin- Madison, Madison, WI Jul 2018- May 2024

- Ph.D. in Applied and Computational Mathematics, GPA: 4.0/4.0, Advisor: Prof. Qin Li
- Specializations: Machine Learning, Gradient Flows and Optimization, AI for Science, Inverse Problems

Department of Mathematical Sciences, Tsinghua University, Beijing, China Sep 2014- Jul 2018

- B.S. in Pure and Applied Mathematics (Second Degree), GPA: 93/100
- Senior Thesis: Modeling and Simulation of Dynamic Property of Metamaterials, Advisor: Prof. Zhongyi Huang
- Specializations: Applied Mathematics, Numerical Analysis, Scientific Computing

Department of Chemical Engineering, Tsinghua University, Beijing, China Aug 2013- Jul 2018

- B.Eng. in Polymer Materials and Engineering, GPA: 91/100, Ranking: 1/27
- Senior Thesis: Simulation of Movement of Microcapsules in Solution with Enzymatic Reactions, Advisor: Prof. Li-Tang Yan
- Specializations: Computational Physics and Chemistry, Engineering Sciences

SKILLS

- Programming Languages: Python (PyTorch, JAX), Matlab, Fortran, C
- Tools: LaTex, AWS Cloud Computing, Azure Cloud Computing, Linux

RESEARCH EXPERIENCE

Department of Mathematics and Institute for Foundations of Data Science, UW-Madison

- Research Assistant Summer 2019, 2020, 2021, Spring 2021, 2022, 2023
- Contributed to 10+ journal and conference publications in collaborations with experts of the field on topics such as deep learning and manifold learning for multiscale PDEs, high performance computing for inverse problems, data assimilation
- Developed and analyzed novel deep learning and manifold learning algorithms for multiscale PDEs in collaborations with Prof. Qin Li and Prof. Stephen J. Wright
- Developed and implemented novel data assimilation algorithms for epidemic forecasting in collaborations with Prof. Qin Li and Prof. Song Gao
- Designed and implemented novel asymptotic stable algorithms for inverse problems of wave type PDEs in collaborations with Prof. Qin Li and Prof. Leonardo Zepeda-Núñez
- Proposed, analyzed and implemented a novel Hamiltonian flow approach for optimization over the manifold of probability measures with Prof. Qin Li, Prof. Oliver Tse and Prof. Stephen J. Wright

SELECTED RESEARCH PROJECTS

Accelerating optimization over the space of probability measures Jan 2023- present

- Proposed and analyzed a Hamiltonian flow approach for optimization over the space of probability measures that extends the momentum-based method and achieves higher order convergence rate for geodesical convex objectives

High-Frequency Limit of Inverse Problems for the Helmholtz equation Oct 2021- present

- Proposed and analyzed a new inverse scattering problem where tightly concentrated monochromatic beams was impinged in the medium and the data was extracted by Husimi transform
- Designed, implemented and tested in Matlab a scalable solver for the new inverse problem using Husimi data

Zero-Loss Convergence of Deep Neural Networks in the Overparameterized Regime Jan 2021- Mar 2023

- Proposed and analyzed a continuous model for the overparameterized deep ResNet that suggested the gradient descent training of the ResNet converged to zero loss if the ResNet is large enough
- Analyzed and proposed a modified back-propagation algorithm for training neural ODEs with higher order

architectures to achieve higher order accuracy

Efficient Multiscale Methods for Nonlinear PDEs Jan 2019- May 2023

- Designed and implemented in PyTorch a neural network-based reduced order Schwarz method for fully nonlinear multiscale elliptic equation and achieved significant speedup over traditional methods
- Designed and implemented in Matlab a manifold learning-based versatile PDE solver that achieved significant improvements in efficacy for different types of nonlinear PDEs
- Proposed and analyzed the optimal basis in multiscale computing and Bayesian homogenization

Projection of COVID-19 Infection Using the Ensemble Kalman Filter Mar 2020- Apr 2020

- Designed and implemented in Matlab an ensemble Kalman filter method by making use of the infection data to analyze a COVID-19 epidemic model that couples the spread in each state
- Proposed and implement models for measures to mitigate the spread and evaluated their effectiveness

PUBLICATIONS

- *Accelerating Optimization over the Space of Probability Measures*
  Shi Chen, Qin Li, Oliver Tse, Stephen J. Wright, arXiv preprint arXiv:2310.04006 (2023).
- *Correcting Auto-Differentiation in Neural-ODE Training*
  Yewei Xu, **Shi Chen**, Qin Li, Stephen J. Wright, arXiv preprint arXiv: 2306.02192 (2023).
- *On Optimal Bases for Multiscale PDEs and Bayesian Homogenization*
  Shi Chen, Zhiyan Ding, Qin Li and Stephen J. Wright, arXiv preprint arXiv: 2305.12303 (2023).
- *Learning Harmonic Molecular Representations on Riemannian Manifold*
  Yiqun Wang, Yuning Shen, **Shi Chen**, Lihao Wang, Fei Ye, Hao Zhou, accepted by *International Conference on Learning Representations 2023*.
- *On the Global Convergence of Gradient Descent for Multi-Layer ResNets in the Mean-Field Regime.*
  Zhiyan Ding, **Shi Chen**, Qin Li and Stephen J. Wright, arXiv preprint arXiv:2110.02926 (2021).
- *High-Frequency Limit of the Inverse Scattering Problem: Asymptotic Convergence from Inverse Helmholtz to Inverse Liouville*
  Shi Chen, Zhiyan Ding, Qin Li, Leonardo Zepeda-Núñez, *SIAM Journal on Imaging Sciences*, 16(1), pp.111-143.
- *Overparameterization of Deep ResNet: Zero Loss and Mean-Field Analysis*
  Zhiyan Ding, **Shi Chen**, Qin Li and Stephen J. Wright, *Journal of Machine Learning Research*, 2022.
- *A Reduced Order Schwarz Method for Nonlinear Multiscale Elliptic Equations Based on Two-Layer Neural Networks*
  Shi Chen, Zhiyan Ding, Qin Li and Stephen J. Wright, accepted by *Journal of Computational Mathematics*, DOI: 10.4208/jcm.2204-m2021-0311.
- *Low-Rank Approximation for Multiscale PDEs*
  Ke Chen, **Shi Chen**, Qin Li, Jianfeng Lu, and Stephen J. Wright, *Notices of the American Mathematical Society*, 69(6).
- *Manifold Learning and Nonlinear Homogenization*
  Shi Chen, Qin Li, Jianfeng Lu, and Stephen J. Wright, *Multiscale Modeling & Simulation*, 20(3), pp.1093-1126.
- *Semiclassical Limit of an Inverse Problem for the Schrödinger Equation*
  Shi Chen and Qin Li, *Research in the Mathematical Sciences*, 8 (3), 1-18, 2021.
- *State-Specific Projection of COVID-19 Infection in the United States and Evaluation of Three Major Control Measures*
  Shi Chen, Qin Li, Song Gao, Yuhao Kang and Xun Shi, *Scientific Reports*, 10 (1), 1-9, **the Top 100 Most Highly Accessed Papers** in 2020 from *Scientific Reports*.
- *Classical Limit for the Varying-Mass Schrödinger Equation with Random Inhomogeneities*
  Shi Chen, Qin Li and Xu Yang, *Journal of Computational Mathematics*, 438, 110365, 2021.
- *How Implementation of Entropy in Driving Structural Ordering of Nanoparticles Relates to Assembly Kinetics: Insight into Reaction-Induced Interfacial Assembly of Janus Nanoparticles*
  Ye Yang, Pengyu Chen, Yufei Cao, Zihan Huang, Guolong Zhu, Ziyang Xu, Xiaobin Dai, **Shi Chen**, Bing Miao, and Li-Tang Yan, *Langmuir*, 2018, 34, 32, 9477–9488

PRESENTATIONS

- **Workshop on Stability Analysis for Nonlinear Partial Differential Equations across Multiscale Applications, Penn. State** Oct 2023
  Talk: Accelerating Optimization over the Space of Probability Measures
- **IFDS Ideas Forum, Univ. of Wisconsin-Madison** Sep 2023
  Talk: Accelerating Optimization over the Space of Probability Measures
- **IFDS Annual Meeting, Univ. of Wisconsin-Madison** Sep 2023
  Poster: Hamiltonian Flows for Optimizing Probability Measures
- **AIMS Special Session on Data-driven Methods in Dynamical Systems, UNC, Wilmington** Jun 2023
  Talk: Zero-loss Neural Network Training in the Mean-field Regime
- **Inaugural CAMDA Conference, Texas A&M University** May 2023
  Talk: Zero-loss Neural Network Training in the Mean-field Regime
- **The Midwest Machine Learning Symposium (MMLS 2023), Univ. of Illinois, Chicago** May 2023
  Poster: Global Convergence of Gradient Descent for Multi-Layer ResNets with Homogeneous Activation Functions in the Mean-Field Regime
- **The International Conference on New Trends in Computational and Data Sciences, Caltech** Dec 2022
  Poster: High-frequency limit of the inverse scattering problem -- from inverse Helmholtz to inverse Liouville
- **SIAM Student Chapter Seminar, Univ. of Wisconsin-Madison** Feb 2022
  Talk: Classical limits of direct and inverse wave type problems -- A Wigner transform approach
- **IMA Workshop of Mathematical Foundation and Applications of Deep Learning, Purdue Univ. (Virtual)** Aug 2021
  Poster Talk: A Reduced Order Schwarz Method for Nonlinear Multiscale Elliptic Equations Based on Two-Layer Neural Networks
- **IFDS Ideas Forum, Univ. of Wisconsin-Madison** Apr 2021
  Talk: Low-Dimensional Approximation to PDE Solution Manifold
- **SIAM Conference on Computational Science and Engineering (Virtual)** Mar 2021
  Poster: Low-Dimensional Approximation to PDE Solution Manifold
- **Data Science Research Bazaar, Univ. of Wisconsin-Madison** Feb 2021
  Poster: State-Specific Projection of COVID-19 Infection in the United States and Evaluation of Three Major Control Measures

CONFERENCE AND MINI-SYMPOSIUM ORGANIZED

- **AIMS Special Session on Data-driven Methods in Dynamical Systems, UNC, Wilmington** Jun 1, 2023

HONORS AND AWARDS

- *Student Travel Support*, AIMS Conference on Dynamical Systems, Differential Equations and Applications 2023
- *Student Travel Award*, 2021 SIAM Annual Meeting (Virtual) 2021
- *Student Travel Award*, 2021 SIAM Conference on Computational Science and Engineering (Virtual) 2021
- *Schaerf Research Award*, University of Wisconsin-Madison, 0.5K 2020
- *Physical Sciences Award*, University of Wisconsin-Madison, 2.5K 2019
- *Academic Excellence Award*, Tsinghua University, China 2016
- *Evergrande Group Scholarship*, Tsinghua University, China, 5K 2015
- *China National Petroleum Scholarship*, Rank 2/110, Tsinghua University, China, 8K 2014
- *First Prize, National Undergraduate Physics Contest*, Beijing, China 2014

TEACHING EXPERIENCE

Department of Mathematics, University of Wisconsin- Madison, Madison, WI

- Teaching Assistant, MATH221, Calculus and Analytic Geometry I Fall 2018, Spring 2020, Fall 2020
- Teaching Assistant, MATH222, Calculus and Analytic Geometry II Spring 2019
- Teaching Assistant, MATH234, Calculus and Analytic Geometry III Fall 2021
- Teaching Assistant, MATH240, Introduction to Discrete Mathematics Spring 2023

- Lecturer Student Assistant, MATH112, Algebra Fall 2023

INDUSTRIAL EXPERIENCE

ByteDance AI Lab, Mountain View, CA (Virtually) May 2022- Nov 2022

- Research Scientist Internship with the Drug AI Team. Mentor: Yiqun Wang

LANGUAGES

English (Full professional proficiency), Chinese (Mandarin and Cantonese, Native proficiency)