Justin Dong

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Education

Brown University **Providence, RI**

Sc.M., Applied Mathematics *2019*

Ph.D., Applied Mathematics 2023

- Thesis: Galerkin neural networks for the approximation of partial differential equations with error control (Advisor: Mark Ainsworth)

Rice University **Houston, TX**

B.A., Computational and Applied Mathematics *2014*

B.S., Mechanical Engineering

Research Interests

- Scientific machine learning
- Numerical methods for PDEs

Publications

- **J. Dong**, S. B. Roberts, S. P. Santos, C. S. Woodward, C. J. Vogl. *High-order time integration methods for cloud microphysics.* In preparation (2024).
- **J. Dong**, M. A. Brunke, X. Zeng, C. J. Vogl, & C. S. Woodward. *Existence and uniqueness in ocean-atmosphere turbulent flux algorithms in E3SM*. In review (2024).
- M. Ainsworth and **J. Dong**. *Extended Galerkin neural network approximation of singular variational problems with error control*. Under revision (2024).
- A. A. Howard, **J. Dong**, R. Patel, M. D'Elia, M. R. Maxey, & P. Stinis. *Machine learning methods for particle stress development in suspension Poiseuille flows*. Rheologica Acta, 1-28 (2023). doi:10.1007/s00397-023-01413-z.
- M. Ainsworth and **J. Dong**. *Galerkin Neural Network Approximation of Multiscale Problems*. Computer Methods in Applied Mathematics and Engineering (2022). doi:10.1016/j.cma.2022.115169.
- M. Ainsworth and **J. Dong**. *Galerkin Neural Networks: A Framework for Approximating Variational Equations with Error Control*. SIAM Journal on Scientific Computing **43**(4). A2474-A2501 (2021). doi:10.1137/20M1366587.
- **J. Dong** and B. Rivière. *A semi-implicit method for incompressible three-phase flow in porous media*. Computational Geosciences **20**(6). 1169-1184 (2016). doi:10.1007/s10596-016-9583-2.
- J. Dong. *A high-order method for three-phase flow in homogeneous porous media*. SIAM SIURO Vol. 7, 2014.

Computer skills

Languages: C/C++, Fortran, Python, MATLAB

API/Library: OpenMP, CUDA, MPI, Tensorflow, Jax

Typesetting: LaTeX

Research & Work Experience

Lawrence Livermore National Laboratory, Livermore, CA **July 2023 – Present**
Postdoctoral Research Scholar

- Analyzed cloud microphysics in global climate models and implemented high-order implicit-explicit (IMEX) and multirate infinitestimal (MRI) time integration methods.
- Improved surface-atmosphere exchange algorithms in Energy Exascale Earth System Model (E3SM) by guaranteeing existence and uniqueness of heat fluxes.

Brown University, Providence, RI **September 2019 – May 2023**
Graduate Student Researcher

- Developed a neural network approach to approximate PDEs based on learning Riesz representers to a sequence of weak residuals.
- Synthesized concepts from both machine learning and traditional Galerkin finite element methods to develop new least squares variational formulations on high-order Sobolev spaces.
- Demonstrated results on challenging problems in solid mechanics (Reissner-Mindlin plates) and fluid dynamics (Stokes flow in non-convex domains).

Pacific Northwest National Laboratory, Richland, WA **May – July 2022**
Research Intern

- Developed a neural network approach for learning closures of monodisperse and bidisperse suspension flows.
- Produced high-resolution approximations of several proposed suspension balance models using neural networks (both Galerkin neural networks and physics-informed neural networks (PINNs) approaches) and analyzed the various models's efficacies in capturing particle scale dynamics.

Lawrence Livermore National Laboratory, Livermore, CA **May – July 2018**
Research Intern

- Implemented a 2D solver for Maxwell's equation using a nodal discontinuous Galerkin finite element method on GPUs.
- Integrated the solver with RAJA – a software abstraction layer for `C++` enabling architecture portability for HPC applications – and mint – a mesh generation package.

Presentations

- Talk: *Galerkin Neural Networks for approximating partial differential equations*. Focused research group seminar on Variationally Stable Neural Networks at UT Austin, University of South Carolina, Georgia Tech, and Portland State University, 2024.
- Talk: *Neural network approximation of singular variational problems*. SIAM Annual Meeting, 2024.
- Talk: *Analysis of fixed point iterations in surface-atmosphere exchange in E3SM*. SIAM Mathematics of Planet Earth, 2024.
- Talk: *Existence and uniqueness analysis of ocean-atmosphere exchange in global climate models*. 18th Copper Mountain Conference on Iterative Methods, 2024.
- Talk: *Galerkin Neural Network Approximation of Multiscale Problems*. SIAM Mathematics of Data Science, 2022.
- Talk: *Galerkin Neural Networks: A Framework for Approximating Variational Equations with Error Control*. SIAM Annual Meeting, 2021.
- Poster: *A High-Order Method for Incompressible Three-Phase Flow in Heterogeneous Porous Media*. SIAM Annual Meeting, 2014.

Honors & Awards

National Science Foundation Graduate Research Fellowship — March 2018

National Defense Science and Engineering Graduate Fellowship (declined) — April 2018

Teaching Experience

- CECS 0915 (Brown University Pre-College): Artificial Intelligence: Modeling Human Intelligence with Networks, instructor (Summer 2021). Developed all course materials, gave lectures, managed teaching assistants, and held office hours for a class of 30 students.
- Applied Mathematics 340: Methods of Applied Mathematics II, head teaching assistant (Spring 2019)
- Applied Mathematics 330: Methods of Applied Mathematics I, head teaching assistant (Fall 2018)

Mentoring Experience

- Arshia Singhal (Ph.D. student): co-mentored a summer internship on accelerating convergence of fixed point iterations in earth system models (Summer 2024); Arshia was awarded Top Presenter at the LLNL Computing Summer Poster Symposium
- Simran Nayak (undergraduate): supervised an independent reading project in adaptive finite element methods for differential equations in one dimension (Fall 2018)
- Daniel Masotti (undergraduate): supervised an independent reading project in preconditioned Krylov subspace methods for large-scale linear systems of equations - ongoing (Spring 2019)
- Emily Reed (undergraduate): supervised an independent reading project in artificial neural networks (Fall 2019)
- Sam Chowning & Arturo Ortiz San Miguel: supervised an independent reading project on singular value decomposition and its applications (Fall 2020)

Professional Service

- Referee: Journal of Computational Physics
- Referee: SIAM Journal on Scientific Computing