YIFAN DU

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EDUCATION

Johns Hopkins University Sept. 2018 - Jan. 2025
Graduate School of Mechanical Engineering *Baltimore, MD*
Ph.D. in Mechanical Engineering
Research assistant

Purdue University Aug. 2016 - March 2018
Graduate School of Mechanical Engineering *West Lafayette, IN*
M.S. in Mechanical Engineering, 3.92/4.0

Sichuan University Sept. 2012 - June 2016
Wu Yuzhang Honors College *Chengdu, China*
B.E. in Water and Hydropower Engineering, 3.70/4.0

RESEARCH INTEREST

Direct numerical simulations, large eddy simulation, inverse problems, PDE-constrained optimizations, machine learning.

PUBLICATIONS

- **Y. Du**, and Tamer A. Zaki. *Vorticity dynamics and detailed Josephson-Anderson relation for flow over a bluff body* (submitted)
- **Y. Du**, and Tamer A. Zaki. *Backward-in-time analysis of vorticity in viscous flow over a bluff body* (submitted)
- **Y. Du**, and Tamer A. Zaki. *Evolutional deep neural network.* Physical Review E 104.4 (2021): 045303.
- **Y. Du**, M. Wang, T. A. Zaki. *State estimation in minimal turbulent channel flow: a comparative study of 4DVar and PINN.* International Journal of Heat and Fluid Flow 99 (2023): 109073.
- V. Mons, **Y. Du**, and T. A. Zaki. *Ensemble-variational assimilation of statistical data in large-eddy simulation.* Physical Review Fluids 6.10 (2021): 104607.
- L. Gao, **Y. Du**, H. Li, G. Lin (2022). *RotEqNet: rotation-equivariant network for fluid systems with symmetric high-order tensors.* Journal of Computational Physics, 461, 111205.
- **Y. Du**, and G. Lin. *Turbulence generation from a stochastic wavelet model. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* 474.2217 (2018): 20180093
- A. Chen*, **Y. Du***, L. Gao*, G. Lin. *Bayesian Data-Driven Discovery of Partial Differential Equations with Variable Coefficients.* Available at SSRN 4747393 (submitted)

HONORS

- Mark O. Robbins Prize in High Performance Computing (2024)
- Mechanical Engineering Departmental Fellowship in Johns Hopkins University (2018)
- China National Scholarship (2013)

RESEARCH EXPERIENCE

Evolutional deep neural network Oct. 2020 - March. 2021
Advisor: Prof. Tamer Zaki *Johns Hopkins University, MD*

- Established the method of Evolutional Deep Neural Network (EDNN) for the solution of time dependent nonlinear partial differential equations
- Train a neural network representing the initial condition for PDE, and predict future solution by evolving network parameters.
- Introduced a method for the embedding of boundary conditions and incompressibility as hard constraints into neural networks.
- Implemented EDNN using Tensorflow. Solved various benchmark PDE problems using EDNN with high accuracy.

Backward-in-time analysis of vorticity in viscous flows over bluff bodies Dec. 2022 - present
Advisor:Prof. Tamer Zaki *Johns Hopkins University, MD*

- Numerically solved the adjoint vorticity equation which represents the stochastic Lagrangian dynamics of vorticity (viscous Kelvin's theorem)
- Investigated the origin of 2D and 3D separation over bluff bodies using adjoint vorticity equation.
- Developed novel vorticity-based theory of 2D and 3D separation.
- Tracked the complex turbulent vortical structures in bluff body flows quantitatively back to their origin.

High Reynolds number flow over a prolate spheroid Jan. 2020 - present
Advisor:Prof. Tamer Zaki *Johns Hopkins University, MD*

- Implemented a 3-dimensional curvilinear multi-block incompressible Navier-Stokes solver with massive parallelization.
- Overlapping grid functionality is implemented for grid non-smoothness on block boundaries.
- Implementation of general MPI interface for data transfer in non-Cartesian topological connection of multi-block data structure.
- Large eddy simulations of flow over prolate spheroid with $Re = 4.2 \times 10^6$.
- Excellent agreement between predicted separation pattern and experimental data.

Detailed Josephson-Anderson relation for flow over bluff body Dec. 2022 - present
Advisor:Prof. Tamer Zaki *Johns Hopkins University, MD*

- Performed direct numerical simulations for flow over a sphere a prolate spheroid at an incidence.
- Numerically verified the detailed Josephson-Anderson relation.
- Quantitatively investigated the vorticity dynamics in the presence of turbulent wake and three-dimensional separation.
- Proposed a physical mechanism for the secondary three-dimensional separation for flow over a spheroid.

Flow reconstruction from sparse measurement using physics informed neural networks March. 2020 - Nov. 2021
Advisor: Prof. Tamer Zaki. Collabrator: Dr. Mengze Wang *Johns Hopkins University, MD*

- Implemented a incompressible Navier-Stokes solver using physics informed neural networks (PINN)
- Reconstructed full resolution velocity and pressure fields from sparse measurements subsampled from high fidelity simulation of turbulent channel flow.
- Detailed comparison between PINN and adjoint based methods.

Ensemble-variational assimilation of statistical data in large-eddy simulation Oct. 2020 - March. 2021
Advisor: Prof. Tamer Zaki. Collabrator: Dr. Vincent Mons *Johns Hopkins University, MD*

- Utilized the ensemble variational method to improve the prediction of statistics in large eddy simulations.
- Explored the structural and coefficient uncertainty of subgrid models in LES using EnVar method.

PRESENTATIONS

- **Y. Du**, *The Evolutional Deep Neural Network for Time-Dependent PDEs.* USACM Student Chapter Seminar Series, U.S. Association for Computational Mechanics, March 27, 2025. (Invited talk)

- **Y. Du**, and T. A. Zaki. *Vorticity dynamics and Josephson-Anderson relation for flow over spheroid.* Bulletin of the American Physical Society (2023).

- **Y. Du**, *Evolutionary deep neural network and fluid dynamics applications*, 2022 Research Symposium on Environmental and Applied Fluid Dynamics

- **Y. Du**, and T. A. Zaki. *Evolutional deep neural networks for accurate Navier-Stokes solutions and forecasts of turbulence.* Bulletin of the American Physical Society 66 (2021).

- **Y. Du**, V. Mons, and T. A. Zaki. *Measurement-augmented large eddy simulations.* APS Division of Fluid Dynamics Meeting Abstracts. 2019.