Tianshu Wen

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LinkedIn ◇ Google Scholar

RESEARCH AREA

numerical optimization · scientific computing · model-order reduction · machine learning · large-scale simulation · finite element method · discontinuous Galerkin · numerical linear algebra · numerical solver

EDUCATION

University of Notre Dame, IN — *Sept. 2019 - Dec. 2024*
Ph.D., Aerospace and Mechanical Engineering — GPA: 4.0/4.0
M.S., Applied and Computational Mathematics and Statistics — GPA: 4.0/4.0

Washington University in St. Louis, MO — *Jan. 2017 - May 2019*
M.S., Mechanical Engineering — GPA: 3.81/4.0

Central Michigan University, MI — *Sept. 2013-Dec. 2016*
B.S., Mechanical Engineering (Minor: Mathematics) — GPA: 3.67/4.0
Academic Honor: *cum laude*

TECHNICAL AND RESEARCH SKILLS

Programming:	C++, Python, MATLAB, Julia, R
Math libraries:	Intel MKL, CBLAS, OpenMP, PyTorch, TensorFlow, JAX, Numpy
Machine learning:	unsupervised learning, supervised learning, physics-informed neural networks (PINNs)
Numerical software:	OpenFOAM, ANSYS (ICEM CFD, FLUENT), COMSOL, NGSolve, Hyperworks
Others:	Pandas, CUDA, MPI, Linux, Git, Intel VTune

PROFESSIONAL EXPERIENCE

Applied Materials, Inc. — Santa Clara, CA
Design Engineer — *Jan. 2025 - Present*

- Currently solving sophisticated inverse design problems using neural networks. The goal is to reduce the development-feedback loop by $\sim 10\times$ (months to days).
- Currently improving multi-objective topology optimization algorithms for AR waveguide design. Cost is reduced by $\sim \mathbf{40}\%$, and convergence rate to the Pareto front is increased by $\sim \mathbf{20}\%$.

Lorentz Solution, Inc. — Santa Clara, CA
Intern, R&D Engineer — *Jun. 2024 - Dec. 2024*

- Developed a **block-accelerated direct solver** from scratch in **C++** for the proprietary computational electromagnetic software (patent-oriented). Designed the solver to leverage **OpenMP** for multi-thread parallelization and developed an optimal memory structure for better performance. Achieved a $\sim \mathbf{5}\times$ speedup over Intel MKL functions.
- Enhanced an existing feature in **Python** for *PeakView*, enabling accurate frequency auto-sweeping in simulations. Introduced UI warnings and implemented default simulation values to handle non-physical user inputs, ensuring robust and error-free performance.

Lawrence Livermore National Laboratory — Livermore, CA
Research Intern supervised by Youngsoo Choi — *Jun. 2023 - Aug. 2023*

- Developed and implemented an Implicit Neural Representation (INR) as a reduced-order model for PDEs in **PyTorch** with approximately $\mathbf{1}\%$ training and $\mathbf{4}\%$ test errors on average. This approach resulted in a speedup of up to **1500x** compared to using a full-order model.
- Employed a **physics-informed loss** to enable the capability of **unsupervised fine-tuning** for the pre-trained model. This fine-tuning improved the model's accuracy by approximately $\mathbf{2}\%$ in the worst test scenario.
- The paper is accepted by **Machine Learning and the Physical Sciences Workshop, NeurIPS 2023**.
- Continued close collaboration after the internship, resulting in the acceptance of a new paper at the **Machine Learning and the Physical Sciences Workshop, NeurIPS 2024**.

University of Notre Dame — Notre Dame, IN
Graduate Research Assistant supervised by Matthew J. Zahr — *Sept. 2019 - Present*

- Developed and implemented a novel trust-region framework in **MATLAB** to efficiently solve optimization problems in large-scale nonlinear systems. Enhanced computational efficiency and solution accuracy by utilizing model hyperreduction, achieving an **18**$\times$ speedup compared with the full-order approach.
- Developed an advanced optimization framework for general PDE-constrained problems, aiming to significantly enhance computational efficiency in large-scale design problems. Achieved a $\mathbf{12.7}\times$ speedup compared with the full-order approach.
- Participated in developing a low-level, in-house finite element package using **MATLAB** and **Julia**.

Washington University in St. Louis St. Louis, MO
Graduate Research Assistant supervised by Ramesh K. Agarwal *Sept. 2017 - May 2019*

- Developed and implemented a transitional flow model into the open-source software **OpenFOAM**, utilizing **C++** and an innovative algebraic intermittency term. Achieved a $\mathbf{4}\times$ reduction in computational cost compared to a conventional four-equation model, enhancing efficiency in flow simulations. The model was officially accepted on NASA TMR.
- Implemented a one-equation eddy-viscosity model, derived from the two-equation k-kL Algebraic Reynolds Stress Model (k-kL-ARSM), into **OpenFOAM**. Demonstrated robust model performance through strong alignment with DNS or experimental data.
- Enhanced the Wall-Distance-Free (WDF) one-equation Wray-Agarwal (WA) model for rough wall flows using the equivalent sand grain approach and implemented it in **OpenFOAM**. Validated the model by achieving alignment with semi-empirical formulas and experimental data, demonstrating its practical applicability and accuracy.

Central Michigan University Mount Pleasant, MI
Undergraduate Research Assistant supervised by Jinxiang Xi *May 2016 - Dec. 2016*

- Conducted Sar-Gel experiments to effectively visualize and analyze aerosol deposition distribution (ADD) within the upper respiratory airway, providing valuable insights into the behavior of nebulized droplets in the respiratory tract.
- Utilized **COMSOL** to model and simulate intrasinus pulsation delivery, exploring the interplay between sinus dosages, pulsating frequency, and nasal morphometry. Cross-validated experimental and theoretical results, providing critical insights for enhancing intrasinus delivery device design.

PUBLICATIONS

Journal Articles

[1] **Wen, T.**, Zahr, M. J., "An augmented lagrangian trust-region method with inexact gradient evaluations to accelerate constrained optimization problems using model hyperreduction," *International Journal for Numerical Methods in Fluids*, fld.5363, Dec. 30, 2024, Link.

[2] **Wen, T.**, Zahr, M. J., "A globally convergent method to accelerate large-scale optimization using on-the-fly model hyperreduction: Application to shape optimization," *Journal of Computational Physics*, p. 112 082, Mar. 2023, Link.

[3] Xi, J., Yang, T., Talaat, K., **Wen, T.**, Zhang, Y., Klozik, S., Peters, S., "Visualization of local deposition of nebulized aerosols in a human upper respiratory tract model," *Journal of Visualization*, vol. 21, no. 2, pp. 225–237, Apr. 2018, Link.

[4] Xi, J., Si, X. A., Peters, S., Nevorski, D., **Wen, T.**, Lehman, M., "Understanding the mechanisms underlying pulsating aerosol delivery to the maxillary sinus: In vitro tests and computational simulations," *International Journal of Pharmaceutics*, vol. 520, no. 1-2, pp. 254–266, Mar. 2017, Link.

Conference Proceedings

[5] **Wen, T.**, Zahr, M. J., "An augmented lagrangian trust-region method to accelerate equality-constrained shape optimization problems using model hyperreduction," in *AIAA SCITECH 2023 Forum (National Harbor, MD)*, American Institute of Aeronautics and Astronautics, Jan. 2023.

[6] Xue, Y., **Wen, T.**, Agarwal, R. K., "Development of a new transitional flow model integrating the one-equation wray-agarwal turbulence model with an algebraic intermittency transport term," in *AIAA Aviation 2021 Forum (Virtual Event)*, American Institute of Aeronautics and Astronautics, Aug. 2021.

[7] **Wen, T.**, Agarwal, R. K., "Development of a One-Equation Algebraic Reynolds Stress Model based on k-kL Closure," in *AIAA Aviation 2019 Forum (Dallas, TX)*, American Institute of Aeronautics and Astronautics, Jun. 2019.

[8] **Wen, T.**, Agarwal, R. K., "A New Extension of Wray-Agarwal Wall Distance Free Turbulence Model to Rough Wall Flows," in *AIAA Scitech 2019 Forum (San Diego, CA)*, American Institute of Aeronautics and Astronautics, Jan. 2019.

Worshops

[9] Kim, M., **Wen, T.**, Lee, K., Choi, Y., *Physics-informed reduced order model with conditional neural fields*, NeurIPS 2024 Workshop: Machine Learning and the Physical Sciences (Vancouver, Canada), *Accepted*, Dec. 2024.

[10] **Wen, T.**, Lee, K., Choi, Y., *Reduced-order modeling for parameterized PDEs via implicit neural representations*, NeurIPS 2023 Workshop: Machine Learning and the Physical Sciences (New Orleans, LA), Nov. 2023.

Thesis

[11] **Wen, T.**, "Adaptive model hyperreduction to accelerate optimization problems governed by partial differential equations," Ph.D. dissertation, University of Notre Dame, 2024.

[12] **Wen, T.**, "Development of One-Equation ARSM-k-kL model and Extension of Wray-Agarwal Turbulence Model to Transitional and Rough Wall Flows," M.S. thesis, Washington University in St. Louis, 2019.

TALKS

Conference and Workshop Presentations

- T. Wen, K. Lee and Y. Choi, "Reduced-order modeling for parameterized PDEs via implicit neural representations," in *NeurIPS 2023 Workshop on Machine Learning and the Physical Sciences* (New Orleans, LA), 12/15/2023
- **(Invited by the session host)** T. Wen and M. J. Zahr, "An augmented Lagrangian method to accelerate constrained optimization using hyperreduction," in *the International Council for Industrial and Applied Mathematics 2023* (Tokyo, Japan), 8/20/2023 - 8/25/2023
- T. Wen and M. J. Zahr, "An augmented Lagrangian trust-region method to accelerate equality-constrained shape optimization problems using model hyperreduction," in *AIAA Science and Technology Forum and Exposition 2023* (National Harbor, MD), 1/23/2023 - 1/27/2023
- T. Wen and M. J. Zahr, "A globally convergent method to accelerate PDE-constrained optimization using on-the-fly model reduction," in *16th U.S. National Congress on Computational Mechanics*, (virtual event), 7/25/2021 - 7/29/2021
- T. Wen and M. J. Zahr, "A globally convergent method to accelerate PDE-constrained optimization using on-the-fly model reduction," in *SIAM Conference on Computational Science and Engineering* (Fort Worth, TX), 3/1/2021 - 3/5/2021
- T. Wen and R K. Agarwal, "Development of a One-Equation Algebraic Reynolds Stress Model based on k-kL Closure" in *AIAA Aviation 2019 Forum* (Dallas, TX), 6/17/2019 - 6/21/2019
- T. Wen and R K. Agarwal, "A new extension of Wray-Agarwal wall distance free turbulence model to rough wall flows" in *AIAA Science and Technology Forum and Exposition 2019* (San Diego, CA), 1/7/2019 - 1/11/2019

Capstone Project Presentations

- T. Wen, D. Huckins, N. Olin, K. Cordy, B. Crombez and C. Yarmak, "Road Load Simulator Fixture Improvement for Nexteer Automotive," in American Society for Engineering Education (ASEE) Poster Exhibition, May 2015

ACADEMIC MEMBERSHIPS & AWARDS

Memberships:

The Society for Industrial and Applied Mathematics (SIAM), *Student Member* — Since 2019

American Institute of Aeronautics and Astronautics (AIAA), *Student Member* — Since 2018

Awards:

16th U.S. National Congress on Computational Mechanics, *Conference Award* — *July 2021*

RESEARCH MENTORING

Undergraduate Students

Chris Myers, *Aerospace and Mechanical Engineering, University of Notre Dame* — *Summer 2022*

Project: Research-level unstructured mesh generation for shock tracking using *ANSYS ICEM CFD* and CFD simulation through *ANSYS FLUENT*.

TEACHING

University of Notre Dame Notre Dame, IN
Teaching Assistant: Since Sept. 2019
AME 30314/30315 Differential Equations, Vibrations, and Control I & II ◇ AME 34331 Fluid Mechanics ◇ AME 60714 Advanced Numerical Methods

Washington University in St. Louis St. Louis, MO
Teaching Assistant: Jan 2018 - May 2019
MEMS 4301: Modeling, Simulation, and Control ◇ MEMS 5001: Optimization Methods in Engineering
MEMS 5410: Fluid Dynamics I ◇ MEMS 5700: Aerodynamics

JOURNAL REFEREE

International Journal of Thermofluids ◇ Sensors ◇ Computation ◇ AgriEngineering ◇ Horticulturae ◇ Agronomy

SELECTED GRADUATE-LEVEL COURSES

University of Notre Dame, IN
Statistical Methods in Data Mining and Prediction ◇ Neural Networks ◇ Time Series Analysis ◇ Advanced Scientific Computing ◇ Python Programming

Washington University in St. Louis, MO
Optimization Methods in Engineering

CERTIFICATIONS

Deep Learning Specialization: Convolutional Neural Networks ◇ Structuring Machine Learning Projects ◇ Improving Deep Neural Networks: Hyperparameter Tuning, Regularization and Optimization ◇ Neural Networks and Deep Learning
Programming: Introduction to C++

REFERENCES

- Prof. Matthew J. Zahr
  Robert W. Huether Collegiate Associate Professor - University of Notre Dame
  Notre Dame, IN 46556
  Phone: 574-631-1298
  Email: mzahr@nd.edu
  Relationship: Ph.D. Research Advisor
- Dr. Youngsoo Choi
  Research Scientist Staff - Lawrence Livermore National Laboratory
  Livermore, CA, 94550
  Email: choi15@llnl.gov
  Relationship: Internship Mentor
- Prof. Ramesh K. Agarwal
  The William Palm Professor of Engineering - Washington University in St. Louis
  St. Louis, MO 63130
  Phone: 314-935-6091
  Email: rka@wustl.edu
  Relationship: M.S. Research Advisor