Tianshu Wen

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RESEARCH INTERESTS

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

EDUCATION

University of Notre Dame, IN *May 2024*
Ph.D., Aerospace and Mechanical Engineering GPA: 4.0/4.0
M.S., Applied and Computational Mathematics and Statistics (in progress)

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

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

TECHNICAL AND RESEARCH SKILLS

Programming:	Main: Python, MATLAB | Java, C++, R
Software & Tools:	**Deep Learning:** PyTorch, TensorFlow | **Others:** Pandas, CUDA, MPI, Linux, Git
Machine Learning:	Time series analysis, Computer vision neural network, Recurrent neural network
Numerical simulation:	OpenFOAM, ANSYS (ICEM CFD, FLUENT), COMSOL, NGSolve, Hyperworks
CAD software:	AutoCAD, CATIA, SOLIDWORKS

RESEARCH EXPERIENCE

Computational Mechanics and Optimization Laboratory Notre Dame, IN
Graduate research assistant supervised by Matthew J. Zahr *Sept. 2019 - Present*

- Developed a new trust-region framework to efficiently solve optimization problems governed by large-scale nonlinear systems of equations using projection-based reduced-order models accelerated with model order hyperreduction and implemented in **MATLAB**.
- The method was performed on fluid shape optimization problems to verify the **global convergence** with speedups over **18x** (accounting for all computational cost, e.g., snapshot collection and data compression) relative to standard optimization approaches.

Computational Fluid Dynamics Laboratory St. Louis, MO
Graduate research assistant supervised by Ramesh K. Agarwal *Sept. 2017 - May 2019*

- Developed a transitional flow model based on an algebraic intermittency term and implemented it into open-source software OpenFOAM using **C++** and saved 4x computational cost compared with a four-equation model. The model was officially accepted on NASA TMR.
- Derived a one-equation eddy-viscosity model from the two-equation k-kL Algebraic Reynolds Stress Model (k-kL-ARSM) and implemented it in OpenFOAM. The model showed good agreement with DNS or experimental data for several wall-bounded flows with small regions of separation.
- Extended the Wall-Distance-Free (WDF) one-equation Wray-Agarwal (WA) model to rough wall flows based on the equivalent sand grain approach and implemented in OpenFOAM. The method had good agreements with a semi-empirical formula and experimental data.

Computational Fluid Dynamics Laboratory Mount Pleasant, MI
Undergraduate research assistant supervised by Jinxiang Xi *May 2016 - Dec. 2016*

- Conducted experiments using Sar-Gel to visualize the aerosol deposition distribution on the inner walls of the upper respiratory airway. The experiments provided feasible means to visualize aerosol deposition distribution (ADD) of nebulized droplets inside the respiratory tract.
- Modeled and simulated the intrasinus pulsation delivery using COMSOL to investigate the relationship between sinus dosages, pulsating frequency, and nasal morphometry. The experimental and theoretical results were cross-validated and essential for improving intrasinus delivery device design.

SELECTED CLASS PROJECTS

University of Notre Dame Notre Dame, IN

Yelp Data Analysis *Summer 2022*

- Conducted data manipulation on the Yelp dataset with over **500 million** rows using **Pandas** to transform the original data to tidy data in preparation for organized analysis and presenting analysis results in an understandable and reproducible manner.
- Visualized the Yelp dataset using **Matplotlib** and **Searborn** to explore relationships between variables such as user reviews, locations, different business categories, etc.

Amazon Robotics Vision *Spring 2022*

- Built a data sourcing and labeling pipeline for object identification tasks for dense clutters. Increased the volume of the training dataset by 400% using data augmentation and increased the test accuracy by 8%.
- Built an object identification framework in **PyTorch** based on **YOLO V5**. The framework was trained using a few hundred photos and obtained above **90%** test accuracy given the 70%-90% surface covered objects in dense clutters.

House Property Price Time Series Prediction *Fall 2021*

- Modeled an **Autoregressive Moving-Average (ARMA)** time series model in **R** to make a short-term (2-3 years) prediction of the prices of houses with different numbers of bedrooms.
- Built a vector-based **long short-term memory (LSTM)** network in **PyTorch** to predict a short-term (2-3 years) house property price with an increase of **46.94%** accuracy compared to the traditional ARMA model.

PUBLICATIONS

Journal Articles

[1] **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*, in review 2022. Link.

[2] 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.

[3] 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

[4] 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," presented at the AIAA Aviation 2021 Forum, VIRTUAL EVENT: American Institute of Aeronautics and Astronautics, Aug. 2, 2021.

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

[6] **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, California: American Institute of Aeronautics and Astronautics, Jan. 2019.

Thesis

[7] **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, Saint Louis, Missouri, 2019.

TALKS

Conference Presentations

- 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

Poster 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:

U.S. Association for Computational Mechanics (USACM), *Student Member* — Since 2021
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

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

SELECTED GRADUATE-LEVEL COURSES

University of Notre Dame, IN
Neural Networks ◇ Time Series Analysis ◇ Advanced Scientific Computing ◇ Python Programming

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

CERTIFICATIONS

Neural Networks and Deep Learning, Coursera — *2021*
Introduction to C++, edX — *2018*