Translational AI Center (TrAC) Seminar Spring 2025

Jessica Zhang

April 29th at 1:00 PM (US Central Time)

Location and zoom link: https://trac-ai.iastate.edu/event/trac-seminar-series-jessica-zhang/

From neurological disorders to additive manufacturing: integrating isogeometric analysis with deep learning and digital twins

Abstract

Coupling physics-based simulation and data-driven modeling have demonstrated great power in predicting complex systems. This talk focuses on integrating an advanced finite element method, isogeometric analysis (IGA), with deep learning and digital twins to address challenging problems of neurological disorders and additive manufacturing (AM). First, we introduce a novel phase field model coupled with tubulin and synaptogenesis concentration to simulate intricate neurite outgrowth and disorders. By integrating IGA and convolutional neural networks, we conduct thorough investigations into the functional role of various parameters affecting the neurodevelopmental disorder with comparison to experimental results. Second, to investigate intracellular transport induced neurodegenerative disorders, we develop a PDE-constrained optimization model to simulate traffic jams induced by microtubule reduction and swirl. We also build a novel IGA-based physics-informed graph neural network to quickly predict normal and abnormal transport phenomena in complex neuron geometries. Finally, in the area of AM, our research focuses on a machine learning framework for inverse design and manufacturing of self-assembling fiber-reinforced composites in 4D printing, IGA-based topology optimization for AM of heat exchangers, as well as data-driven residual deformation prediction and lattice support structure design in the laser powder bed fusion (LPBF) AM process. Our on-going efforts aim to predict stress-induced build failures using dynamic neural surrogates, where reduced order modeling is a key technique to efficiently simulate underlying physics.

Speaker Bio

Jessica Zhang is the George Tallman Ladd and Florence Barrett Ladd Professor of Mechanical Engineering at Carnegie Mellon University, with a courtesy appointment in Biomedical Engineering. She earned her B.Eng. in Automotive Engineering and M.Eng. in Engineering Mechanics from Tsinghua University, and her M.Eng. in Aerospace Engineering and Ph.D. in Computational Engineering and Sciences from The University of Texas at Austin. Her research interests include computational geometry, isogeometric analysis, finite element method, data-driven simulations, and image processing, with a strong focus on their applications in computational biomedicine and engineering. Zhang has co-authored over 240 publications in peer-reviewed journals and conference proceedings and is the author of the book Geometric Modeling and Mesh Generation from Scanned Images (CRC Press). Her work spans both theoretical development and practical applications, contributing significantly to advancements in both fields. She is a Fellow of prominent societies, including SIAM, ASME, IACM, USACM, IAMBE, AIMBE, SMA, IMR and ELATES at Drexel, highlighting her distinguished reputation in the field. Currently, she serves as the Editor-in-Chief of Engineering with Computers, further establishing her leadership in computational science and engineering research. Zhang has received numerous awards, including two recent major recognitions: 2025 ASME Van C. Mow Medal for her meritorious contributions to the field of bioengineering and 2025 AWM-SIAM Sonia Kovalevsky Lecture Award for her achievements in applied and computational mathematics.

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