香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

土木及環境工程學系
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

HKSTAM 香港力學學會

HKSTAM Distinguished Lecture and HKUST CIVL Joint Seminar

JOINT SEMINAR

CONVOLUTION HIERARCHICAL DEEP LEARNING NEURAL NETWORK (C-HIDENN)-AI: FROM TOPOLOGICAL OPTIMIZATION TO ADDITIVE MANUFACTURED MATERIALS

Speaker

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Co-Founder of HIDENN-AI, LLC

Abstract

In recent years, the integration of deep learning-based universal approximation and traditional numerical methods has led to the development of a new computational science theory, called Hierarchical Deep-learning Neural Network (HiDeNN). An AI system has been created to leverage these capabilities, achieving unprecedented speed and accuracy compared to conventional numerical methods for solving problems with limited physics and extensive computational requirements. The HiDeNN-AI system offers multi-resolution analysis with automatic adaptivity refinement and built-in Convolutional interpolants for higher-order accuracy. A new mathematical theory, C-HiDeNN-TD which is carefully design with controlling parameters: s-patch size, a-dilation, p-order of polynomial and g-any other interpretable parameters, has been proposed under the HiDeNN-AI framework by combining Tensor Decomposition (TD) with Convolution-HiDeNN, allowing for faster and more accurate solutions to large-scale problems. Here, we demonstrate the newly developed capabilities of C-HiDeNN-TD by solving a large-scale topological optimization problem, which involves concurrent design and optimization of N-meso-scale lattice structures and M-microscale materials systems. The concurrent design optimization theory (C-HiDeNN-TD-TO) at multiple scales ensures lightweight construction and desired performance, which can be manufactured through 3D printing. Additionally, the HiDeNN-AI framework is showcased by developing a digital twin of additive manufacturing materials systems. This approach utilizes multi-fidelity and multimodal data from both experiments and physics-based process simulations to construct a surrogate model for real-time prediction and online process control and monitoring. The HiDeNN-AI system is capable of accounting for uncertainties in the experimental process and unresolved physics in the simulations, making it a powerful tool for predicting the performance of additive manufacturing materials.

Biography

Professor Liu, Walter P. Murphy Professor of Northwestern University, Co-founder of HIDENN-AI, LLC, Past President of the International Association for Computational Mechanics (IACM), Past Chair and Chair of the US National Committee on TAM and Member of Board of International Scientific Organizations, both within the US National Academies. Selected synergistic activities includes development of ICME multiscale data-driven theories and software for design and manufacturing of composites material systems, additive manufacturing, and technology transfer. He has 40 years of engineering and manufacturing consulting for more than 20 organizations. Research.com, a prominent academic platform for scientists, listed Professor Wing Kam Liu #23 in the world ranking and #14 in United States published in the 2023 Edition Ranking of Top 1000 Scientists in the area of Mechanical and Aerospace Engineering. Liu's selected honors include the 2018 and 2022 NIST AM Benches Challenges, the 2020 First place in the National Center for Defense Manufacturing and Machining for the competition in the Air Force Research Laboratory Additive Manufacturing Modeling Challenge Series ($52,000 prize is donated to the NU Mechanical Sciences Donor-Advised Fund), Japan Society of Computational Engineering Sciences Grand Prize; Computational Mechanics Award from Japanese Society of Mechanical Engineers; Honorary Professorship from Dalian University of Technology, IACM Gauss-Newton Medal (highest honor) and Computational Mechanics Award; ASME Dedicated Service Award, ASME Robert Henry Thurston Lecture Award, ASME Gustus L. Larson Memorial Award, ASME Pi Tau Sigma Gold Medal and ASME Melville Medal; John von Neumann Medal (highest honor) and Computational Structural Mechanics Award from the US Association of Computational Mechanics (USACM). He was the founding Director of the NSF Summer Institute on Nano Mechanics and Materials and Founding Chair of the ASME NanoEngineering Council. He is the editor of two International Journals and honorary editor of two journals and has been a consultant. Liu has written five books including "Mechanistic Data Science for STEM Education and Applications," Springer, to be published by November 2021. He is a Fellow of ASME, ASCE, USACM, AAM, and IACM.

20 September 2023
Wednesday

10:00 am - 11:00 am

Civil Engineering Conference Room
Room 3574 (Lift 27/28)
HKUST

Zoom Link
Meeting ID: 931 2815 5438
Passcode: HKSTAM

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