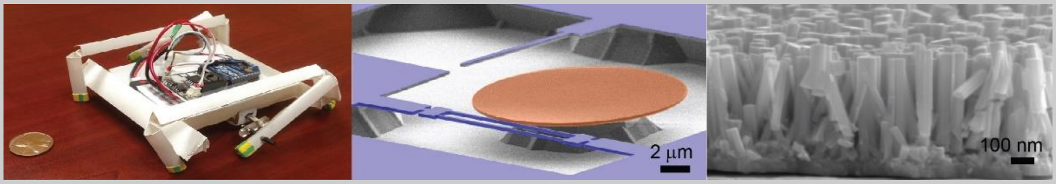
WPI MECHANICAL ENGINEERING



Functionally Graded Lattice Structure Design for Additive Manufacturing and Physics-informed Convolutional Network for Data-driven Multiscale Analysis

Dr. Lin Cheng
Department of Mechanical Engineering
Northwestern University

11:00am -12:00 pm, Thursday, May 13th
Zoom Link: https://wpi.zoom.us/j/92980938400

This seminar will cover two sub-topics in computational design and physics-informed deep learning models for multiscale analysis. First, I will present an efficient homogenization-based topology optimization method for optimizing the design of functionally graded lattice infills in AM components for weight savings and performance enhancement. The motivation for developing this method is to overcome the inability of the conventional topology optimization method to eliminate overhangs that are not self-supporting in AM. The proposed method takes advantage of the self-supporting nature of lattice structures and the tunable thermal and mechanical properties of lattices by varying their strut size. The method has been validated by comparing results obtained by the homogenized model, direct numerical simulation, and experimental testing of several optimized components produced by AM.

Second, I will present a fully convolutional network (FCN) for data-driven representative volume element (RVE) analysis to accelerate the discovery of effective macroscopic behavior, identify microscale material properties, and automatically characterize defects in materials. The FCN framework takes microstructure images, parameterized by a Heaviside representation coupled with a level-set field, and loading conditions as inputs. The aim is to directly learn nonlinear interaction between the microstructure and local response of the RVE in a hierarchical manner through feature engineering. This avoids the burdensome discretization and interpolations, making it possible to transfer the learned structure-response from one microstructure to another microstructure, thus significantly accelerating the modeling of heterogeneous materials. Moreover, additional layers of convolution for vectorized material characterization and differentiation operation are proposed in the FCN framework, which allows the data-driven discovery of unknown variables and fields and thus unifies the analysis and characterization for the multiscale analysis. It has been demonstrated that the framework can leverage the power of graphics processing units in parallel RVE analysis, microstructure-based transfer learning, inverse derivation of material constituents, and characterization of material defects.

About the Speaker

Lin Cheng is currently a postdoctoral researcher in the Department of Mechanical Engineering at Northwestern University under the supervision of Professor Gregory Wagner and Professor Wingkam Liu. Dr. Cheng holds a Ph.D. in mechanical engineering from the University of Pittsburgh. He received his B.S. degree from Xi'an Jiao Tong University and M.S. degree from Shanghai Jiao Tong University, all in mechanical engineering.

His current research interests lie in physics-informed deep learning and computational design for metal additive manufacturing. The design optimization methods developed by him have been adopted and implemented by ANSYS in their engineering simulation software. Dr. Cheng has 23 peer-reviewed journal publications in journals such as *Additive Manufacturing*, *Computer Methods in Applied Mechanics and Engineering*, etc. He won 1st place in a student poster competition at the RAPID conference in 2017 for presenting his work on lattice infill optimization and received the Best RA Award in Mechanical Engineering at the University of Pittsburgh in 2018.