Translational AI Center (TrAC) Seminar Spring 2024

Nonlocal Operator Learning is All You Need

Prof. Yue Yu
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Faculty host: Ming-Chen Hsu

March 20th at 1:00 PM (US Central Time) in 2206 SICTR

More information: https://trac-ai.iastate.edu/event/trac-seminar-series-yue-yu/

Abstract

During the last 20 years there has been a lot of progress in applying neural networks (NNs) to many machine learning tasks. However, their employment in scientific machine learning with the purpose of learning complex responses of physical systems from experimental measurements has been explored much less. Unlike classical machine learning tasks, such as computer vision and natural language processing where a large amount of unstructured data are available, physics-based machine learning tasks often feature scarce and structured measurements.

In this talk, we will consider learning of heterogeneous material responses as an exemplar problem to investigate automated physical model discovery from experimental data. In particular, we propose to parameterize the mapping between excitation and corresponding system responses in the form of nonlocal neural operators, and infer the neural network parameters from experimental measurements. As such, the model is built as mappings between infinite-dimensional function spaces, and the learnt network parameters are resolution-agnostic: measurements with different resolutions can be integrated to train the same model. Moreover, the nonlocal operator architecture also allows the incorporation of fundamental mathematical and physics knowledge, which further improves the learning efficacy and robustness from scarce measurements.

To demonstrate the applicability of our nonlocal operator learning framework, three typical scenarios in physics-based machine learning will be discussed: (1) learning of a material-specific constitutive law, (2) learning of an efficient PDE solution operator, and (3) development of a foundation constitutive law across multiple materials. As an application, we learn material models directly from digital image correlation (DIC) displacement tracking measurements on a porcine tricuspid valve leaflet tissue, and we will show that the learnt model substantially outperforms conventional constitutive models.

Biography

Dr. Yue Yu received her B.S. from Peking University in 2008, and her Ph.D. from Brown University in 2014. She was a postdoc fellow at Harvard University after graduation, and then she joined Lehigh University as an assistant professor of applied mathematics and was promoted to full professor in 2023. Her research lies in the area of numerical analysis and scientific computing, with recent projects focusing on nonlocal problems and scientific machine learning. She has received an NSF Early Career award and an AFOSR Young Investigator Program (YIP) award.

This seminar counts towards the ME 600 seminar requirement for Mechanical Engineering graduate students.
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Free pizza will be provided at the event!!!