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Physics-Informed Machine Learning for Physics-Based Data-Driven Design and Manufacturing

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Seminar Details

Friday, October 25, 2024 2:30pm – 4:00pm

*UH Campus
Classroom & Business Building
Room CBB 104*

Online via Teams https://www.cive.uh.edu/research/beyer-distinguished-lecture

ABSTRACT: The essential task in designing products, materials, or processes is to establish the process-structure-property relationships that enable design optimization. The task, however, is challenging, because the relationships are usually in a high-dimensional space with a large number of design variables. It is very costly to rely only on experiments or physics-based simulations to explore the solution space. Therefore, empirical and data-driven machine learning models can be useful. Nevertheless, data sparsity is the main barrier of using the latest machine learning tools as the surrogates in engineering applications. In the past several years, we developed a general framework of physics-informed neural networks to tackle the data sparsity challenge by applying physical models as the constraints to guide the training of neural networks. Novel adaptive weighting scheme as well as multi-fidelity and minimax architectures were proposed to predict complex multiphysics phenomena. To quantify uncertainty, new physics-constrained Bayesian neural networks were also proposed. The new framework has been applied to engineering design problems such as heat transfer and phase transition, as well as predictions of temperature, dendritic growth, and grain coarsening to optimize additive manufacturing processes, in combination with scalable Bayesian optimization and physics-based models such as the phase-field thermal lattice Boltzmann method and kinetic Monte Carlo. In addition, to maximize the information gain from limited sensor data in process monitoring, we proposed a physics-based compressive sensing framework to solve the inverse problem reliably based on domain knowledge. To improve the efficiency of data collection, we also developed a physics-constrained dictionary learning approach to enable data compression, sensor placement optimization, and diagnosis simultaneously.

BIOGRAPHY: Yan Wang is a Professor of Mechanical Engineering and leads the Multiscale Systems Engineering research group at the Georgia Institute of Technology. The research of the group is at the intersection of design, manufacturing, and materials. His interests include materials design, uncertainty quantification, physics-informed machine learning, and quantum scientific computing. He has co-authored over 240 refereed journal and conference publications, including the ones with best paper awards at the conferences of American Society of Mechanical Engineers (ASME), The Minerals, Metals & Materials Society (TMS), the Institute of Industrial & Systems Engineers (IISE), and the International CAD Conference. He is a recipient of the U.S. National Science Foundation CAREER Award, a National Aeronautics and Space Administration (NASA) Faculty Fellow, and an ASME Fellow. He currently serves as the Editor-in-Chief of the ASME Journal of Computing and Information Science in Engineering.