Structural Engineering Seminar Series

CEE 595 S

Adaptive finite element methods and machine-learning-based surrogates for the phase field fracture model

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Abstract:

Modeling and understanding fracture propagation is necessary to improve the safety and reliability of engineering materials and structures and to design them better with enhanced mechanical properties (e.g. tensile strength, and fracture resistance). Over the last decade, phase field approach to fracture emerged as robust computational methodology, owing to its ability to simulate complex crack morphologies, including splitting and merging. However, one of the main challenges with applying the phase field approach to real-world problems is the computational cost associated with resolving the diffuse crack interface. Adaptive finite element methods and machine-learning-based model surrogates offer the potential to enable efficient and scalable simulation strategies. In this talk, I will give an overview of my research work conducted in the past five years. First, I will present my collaborative work on adaptive continuous/discontinuous Galerkin finite element methods for phase field fracture simulations. I will discuss the formulation of strain-energy and stress-based crack driving force functions and their calibration and validation with experimental data performed as a part of the damage mechanics challenge. Second, I will present a CNN-based surrogate for the phase field fracture model that can predict damage/stress field given the microstructure. I will discuss the accuracy of the surrogate model for predicting the uniaxial tensile strength of fiber-reinforced composite microstructures and its potential use in inverse design aimed at maximizing tensile strength. I will end with some concluding remarks and vision for future work on parallel scalable implementation of crack evolution (SPICE).

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Bio:

Dr. Ravindra Duddu got his B. Tech in Civil Engineering from the IIT Madras, and his M.S. and Ph.D. in Civil and Environmental Engineering from Northwestern University. He worked as a postdoctoral researcher at the University of Texas at Austin and Columbia University, New York, before joining Vanderbilt University. His research interests are in computational solid mechanics with a focus on multi-physics modeling of material damage evolution in natural and man-made materials. He is a recipient of the Vanderbilt Chancellor Faculty Fellowship, NSF early CAREER award, Fulbright Kalam-Climate Fellowship, The Royal Society International Exchanges award, and ONR Summer Faculty Fellowship. He is the past Chair of technical committees on Computational Mechanics and Fracture and Failure Mechanics associated with ASCE and ASME, and incoming Chair of USACM Energy & Earth Systems technical thrust area.

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