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An Automated Computational Framework for Modeling Materials with Complex Microstructures

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Friday, September 1, 2017
2:00 PM - Ryon Lab 201

Summary: Simulating the mechanical behavior of materials with complex microstructures has been a long-standing challenge in the field of computational mechanics. This presentation introduces a new mesh generation algorithm, named Conforming to Interface Structured Adaptive Mesh Refinement (CISAMR), for creating high fidelity finite element models of such problems. CISAMR transforms a simple structured grid into a high-quality conforming mesh with appropriate element aspect ratios and negligible discretization error using a *non-iterative* algorithm. Similar to eXtended FEM (XFEM), CISAMR preserves the original structure of the background grid after the construction of conforming elements. Moreover, unlike conventional mesh generation algorithms such as Octree-based methods, CISAMR does not relocate any of the nodes of the background mesh other than those cut by the interface; thus no iterative smoothing or relaxation process would be necessary. To fully automate the modeling process, CISAMR is integrated with a novel microstructure reconstruction algorithm relying on statistical and morphological information extracted from digital data such as micro-Computed Tomography (micro-CT) images. This algorithm not only can reconstruct microstructural models with realistic fibers/inclusions shapes but also can accurately synthesize the target volume fraction and spatial arrangement of these heterogeneities. The current presentation demonstrates the application of the resulting integrated computational framework for studying the multiscale failure response of a variety of composite materials subject to thermo-mechanical loadings, including metal matrix composites, heterogonous adhesives, and carbon fiber reinforced polymers.

Bio: Dr. Soheil Soghrati is an assistant professor of Mechanical and Aerospace Engineering & Materials Science and Engineering at The Ohio State University (OSU). He earned his PhD in Structural Engineering with Minor in Computational Science in Engineering from the University of Illinois at Urbana-Champaign and received his Masters and Bachelor degrees in Civil Engineering from Isfahan University of Technology. Dr. Soghrati joined the Department of Mechanical and Aerospace Engineering at OSU in June 2013 with a joint appointment in the Department of Materials Science and Engineering. He is also one of the steering board faculty members of the Simulation Innovation and Modeling Center (SIMCenter) at OSU. Dr. Soghrati's research interests lay in the area of computational solid mechanics, with special focus on the development and application of advanced methods for the automated modeling of problems with complex/evolving morphologies. Some of the ongoing research projects in his research group include simulating localized corrosion processes, multiscale failure response of composite materials, modeling non-woven entangled materials, and computational design of Lithium-ion battery electrodes.