MAE Graduate Seminar Series
April 26th, 2019
Invited Speaker: Peter Grimmer, Sandia National Laboratories
Seminar title: Multiscale uncertainty propagation for fasteners

Abstract:

Finite element models of complex structures are used to predict how structures respond to extreme environments. This involves severe loading scenarios that cause material failure, which can greatly affect the structural response. To accurately predict material failure processes detailed models must be used. It is impractical to simulate a model of an entire structure with the level of detail needed to accurately predict failure. This motivates multiscale methods that can include fine details in critical areas, while using a coarser system level model to maintain computational tractability. This work does not seek to develop a new multiscale numerical method, but rather to demonstrate a novel use of one for uncertainty propagation (UP) to efficiently gain statistics about system mechanical failure. Here, we demonstrate the developments for a housing with threaded fasteners, representing the fasteners with various levels of geometric fidelity. Here we use a simple joint with four screws as an example of a system that benefits from our multiscale uncertainty propagation approach. In this problem, the failure of the individual bolts in the joint governs the system response. Predicting the fracture in a bolt requires a high level of detail that cannot be included for every bolt in a complex system. The constitutive response (e.g., yield load, ultimate load, elongation-to-failure) of each individual bolt in our example joint varies randomly according to distributions determined from fastener testing. In general, sampling-based methods can be used to understand the effect uncertain inputs have on the system response. Here, the uncertain fastener constitutive parameters were optimally described by a stochastic reduced-order model (SROM), which is a set of parameters that optimally samples the parameter space. This SROM was used to construct a surrogate model of the joint's response using the low fidelity joint model. This surrogate was then sampled 10,000 times to inform which bolt to replace in the low fidelity fastener model with a much higher-fidelity, helical-threaded fastener model using multi-point constraints to couple the models. The results compare the frameworks' estimates of probability of failure against direct numerical simulation for "truth''.

Bio:

Peter Grimmer is a member of the technical staff in the Component Science and Mechanics department at Sandia National Laboratory. He did his undergraduate and master's degrees in Engineering Mechanics at the University of Wisconsin, where he researched the mechanics of soft, fibrous biological materials. Now at Sandia he works in nonlinear solid mechanics, researching calibration methods for reduced order models as well methods to propagate uncertainty across length scales for multi-fidelity modeling.