Numerical Analysis and Scientific Computing Seminar

Nonlocal Models in Computational Science and Engineering

Marta D'Elia
Sandia National Lab

Abstract: Nonlocal continuum theories such as peridynamics and nonlocal elasticity can capture strong nonlocal effects due to long-range forces at the mesoscale or microscale. For problems where these effects cannot be neglected, nonlocal models are more accurate than classical Partial Differential Equations (PDEs) that only consider interactions due to contact. However, the improved accuracy of nonlocal models comes at the price of a computational cost that is significantly higher than that of PDEs.

In this talk, I will present nonlocal models and the Nonlocal Vector Calculus, a theory that allows us to treat nonlocal diffusion problems in almost the same way as PDEs. Furthermore, I will present current open challenges related to the numerical solution of nonlocal problems and show how we are currently addressing them. Specifically I will describe an optimization-based local-nonlocal coupling strategy and briefly introduce a technique to improve the performance of Finite Element (FE) approximations. The goal of local-nonlocal coupling methods is to combine the computational efficiency of PDEs with the accuracy of nonlocal models. These couplings are imperative when the size of the computational domain or the extent of the nonlocal interactions are such that the nonlocal solution becomes prohibitively expensive to compute, yet the nonlocal model is required to accurately resolve small scale features. Our approach formulates the coupling as a control problem where the states are the solutions of the nonlocal and local equations, the objective is to minimize their mismatch on the overlap of the nonlocal and local domains, and the controls are virtual volume constraints and boundary conditions. I will present consistency and convergence studies and, using three-dimensional geometries, I will also show that our approach can be successfully applied to challenging, realistic, problems.

Finally, I will briefly introduce a new concept of nonlocal neighborhood that helps improving the performance of FE methods and show how our approach allows for fast assembling in two-dimensional computations.

Friday, October 26, 2018, 10:00 am
Atwood 215

Mathematics
Emory University