Accelerating modeling & simulation workflows via the Schwarz alternating method for multi-scale coupling and contact

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Multi-scale methods are crucial for understanding and predicting the behavior of engineering systems where small-scale events influence overall performance. This talk presents a novel approach for concurrent multi-scale coupling in finite deformation solid mechanics using the Schwarz alternating method (SAM). This methodology leverages known solutions to partial differential equations (PDEs) in simpler domains to iteratively construct solutions for more complex domains.

The first part of this talk focuses on overlapping and non-overlapping variants of SAM for high-fidelity finite element models in solid mechanics. I will demonstrate on some large-scale numerical examples simulated using Sandia's Sierra/Solid Mechanics code that this method can accelerate mod/sim workflows and simplify the meshing of complex geometries.

In the second part of the talk, I will discuss some recent extensions of overlapping SAM to couple high-fidelity models with non-intrusive Operator Inference (OpInf) reduced order models (ROMs), facilitating the integration of data-driven models into existing multi-scale frameworks. Numerical examples will illustrate runtime reductions, as well as the potential for improving the predictive viability of projection-based ROMs through spatial localization and online integration of high-fidelity information.

Finally, time permitting, I will introduce a novel contact enforcement approach rooted in non-overlapping SAM. By treating each body as a separate, non-overlapping domain and preventing interpenetration using an alternating Dirichlet-Neumann iterative process, our approach eliminates the need for contact constraints and offers great flexibility with respect to meshing. I will show through numerical examples that the approach yields enhancements in accuracy and energy conservation compared to traditional methods.