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Flexible domain decomposition-based couplings of conventional and data-driven models via the Schwarz alternating method

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This talk will describe some recent advancements in developing a rigorous mathematical framework for the domain decomposition-based coupling of arbitrary combinations of first-principles numerical methods (i.e., full order models or FOMs) with data-driven models (i.e., projection-based reduced order models or ROMs) under the flexible Heterogeneous Numerical Methods (fHNM) project at Sandia National Laboratories. Specifically, I will present a recent extension of the Schwarz alternating method [1,2] that enables the creation of FOM-ROM and ROM-ROM couplings from nonlinear monolithic problems [3]. This method works by performing an overlapping or non-overlapping domain decomposition (DD) of the physical domain, and solving a sequence of problems on these subdomains, with information propagating through carefully-constructed transmission conditions on the subdomain boundaries. The solution in each subdomain may be characterized by much simpler, localized dynamics, and hence more easily modeled and solved. We will showcase recent results obtained by implementing this method in the open-source Pressio demo-apps library, which demonstrate that the Schwarz alternating method is capable of delivering stable and accurate hybrid models when applied to advection-dominated fluid flow problems with moving shocks, for which monolithic approaches are prohibitively expensive or grossly inaccurate. We will additionally demonstrate that online CPU-time gains are achievable through an implementation of the additive variant of the Schwarz alternating method, which admits more parallelism by solving all subdomain-local problems simultaneously on different processes/threads. Time-permitting, we will describe some ongoing work aimed at developing an automated learning algorithm leveraged to select "optimal" (i.e, accuracy and efficiency maximizing) DDs and ROM vs. FOM placements/assignments.

References

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