CREATION OF HYBRID FULL ORDER-REDUCED ORDER MODELS VIA DOMAIN DECOMPOSITION AND THE SCHWARZ ALTERNATING METHOD

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Projection-based model order reduction is a promising data-driven strategy for reducing the computational complexity of numerical simulations by restricting the search of the solution to a low-dimensional space spanned by a reduced basis constructed from a limited number of high-fidelity simulations and/or physical experiments/observations. While recent years have seen extensive investments in the development of projection-based reduced order models (ROMs) and other data-driven models, these models are known suffer from a lack of robustness, stability and accuracy, especially in the predictive regime. Moreover, a unified and rigorous theory for integrating these models in a “plug-and-play” fashion into existing multiscale and multi-physics coupling frameworks is lacking at the present time.

This talk presents a promising mitigation to the aforementioned shortcomings via the Schwarz alternating method for domain decomposition (DD), recently developed to enable consistent and concurrent multi-scale coupling of finite element FOMs in solid mechanics [1, 2]. In our approach, the physical domain on which a difficult problem is posed is decomposed into a set of overlapping or non-overlapping subdomains, and spatially-local ROMs are constructed in one or more of these subdomains; the ROMs are subsequently coupled with each other and/or with full order models (FOMs) in neighboring subdomains through carefully-defined transmission boundary conditions applied at interface boundaries and the Schwarz iteration procedure [3]. We present results on several problems exhibiting a slow decay of the Kolmogorov $n$-width, demonstrating that the proposed coupling methodology is computationally efficient and capable of coupling disparate models without introducing numerical artifacts into the solution. Importantly, our results suggest that FOM-ROM and ROM-ROM couplings of the sort considered have the potential of improving the predictive viability of projection-based ROMs, by enabling the spatial localization of ROMs (via DD) and the online integration of high fidelity information into these models (via FOM coupling).

REFERENCES