The Schwarz alternating method for dynamic multi-scale coupling in solid mechanics

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Concurrent multiscale methods for solid mechanics are essential for the understanding and prediction of behavior of engineering systems when a small-scale event will eventually determine the performance of the entire system. In [1], the domain-decomposition-based Schwarz alternating method was proposed as a means for concurrent multiscale coupling in finite deformation quasistatic solid mechanics. It was proven that the method converges to the single-domain solution provided each of the subdomain problems is well-posed, and that the convergence rate is geometric. The method was implemented in Sandia's Albany/LCM research code, and demonstrated to have a number of appealing features and advantages over completing multiscale coupling methods, most notably its concurrent nature (i.e., it's ability to exchange information back and forth between small and large scales), its ability to couple non-conformal meshes with different element topologies, and its non-intrusive implementation into existing codes. Accuracy, convergence and scalability of the proposed method was demonstrated on several numerical examples.

This talk will focus on some recent extensions of the Schwarz alternating formulation to *dynamic* solid mechanics problems. As with the quasi-static version of the method, the basic idea is to use the solution of a partial differential equation (PDE) on two or more regularly shaped domains comprising a more complex domain to iteratively build a solution for the more complex domain. Our dynamic Schwarz formulation is *not* based on a space-time discretization like other dynamic Schwarz-like methods; instead, it uses a governing time-stepping algorithm that controls time-integrators within each subdomain. As a result, the method is straight-forward to implement into existing codes (e.g, Albany/LCM), and allows the analyst to use different time-integrators with different time steps within each domain. We demonstrate on several test cases that coupling using the proposed method introduces no dynamic artifacts that are pervasive in other coupling methods (e.g., spurious wave reflections near domain boundaries), regardless of whether the coupling is done with different mesh resolutions, different element types like hexahedral or tetrahedral elements, or even different time integration schemes, like implicit and explicit. Furthermore, on dynamic problems where energy is conserved, we show that the method is able to preserve the property of energy conservation.

REFERENCES

[1] A. Mota, I. Tezaur, C. Alleman. "The alternating Schwarz method for concurrent multiscale coupling", *Comput. Meth. Appl. Mech. Engng.* 319 (2017) 19-51.