The Schwarz Alternating Method for Multiscale Coupling in Solid Mechanics

Alejandro Mota[*], **Irina Tezaur***, Coleman Alleman[*], Greg Phlipot[†]

[*] Sandia National Laboratories, Livermore, CA 94551, USA.
e-mail: ikalash@sandia.gov, web page: www.sandia.gov/~ikalash
[†] California Institute of Technology, Pasadena, CA 91125, USA.

ABSTRACT

Concurrent multiscale methods 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. Here, we describe the recently-proposed [1] domain-decomposition-based Schwarz alternating method as a means for concurrent multiscale coupling in finite deformation quasistatic and dynamic solid mechanics. The approach is based on the simple idea that if the solution to a partial differential equation is known in two or more regularly shaped domains comprising a more complex domain, these local solutions can be used to iteratively build a solution for the more complex domain. The proposed approach has a number of advantages over competing multiscale coupling methods, most notably its concurrent nature, its ability to couple non-conformal meshes with different element topologies (Figure 1), and its non-intrusive implementation into existing codes.

In this talk, we will first overview our original formulation of the Schwarz alternating method for multiscale coupling in the context of quasistatic solid mechanics problems [1], described in a COUPLED 2017 presentation. We will discuss the method's proven convergence properties, and demonstrate its accuracy, convergence and scalability of the proposed Schwarz variants on several quasistatic solid mechanics examples simulated using the Albany/LCM code.

The bulk of the talk will present some recent extensions of the Schwarz alternating formulation to *dynamic* solid mechanics problems [2]. 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-integrator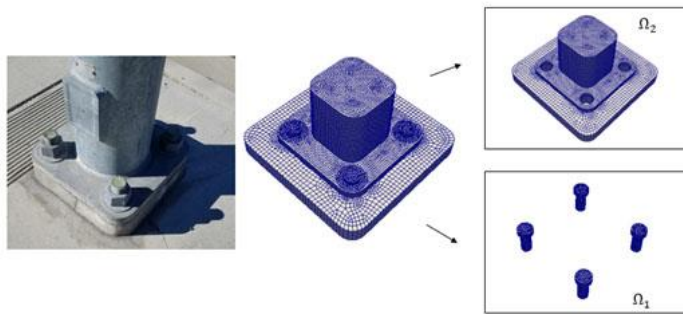s within each subdomain. As a result, the method is straightforward to implement into existing codes (e.g, Albany/LCM), and allows the analyst to use different time-integrators with different time steps within each domain. We demonstrate on several test cases (including bolted-joint problems of interest to production; e.g. Figure 1) 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.

Figure 1: Schwarz Domain Decomposition for Production-Like Bolted-Joint Geometry

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.
[2] A. Mota, I. Tezaur, G. Phlipot. "The Schwarz alternating method for dynamic solid mechanics", in preparation for submission to *Comput. Meth. Appl. Mech. Engng.*