The Schwarz alternating method as a means for concurrent multiscale coupling in solid mechanics

Alejandro Mota[1], **Irina Tezaur [1,*]**, Coleman Alleman[1], Greg Phlipot[2]
[1]Sandia National Laboratories, [2]MSC Software Corporation, *ikalash@sandia.gov

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. This talk will describe the recently-proposed [1,2] 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, its non-intrusive implementation into existing codes, and, for the dynamic case, it's ability to couple subdomains that each use their own time-step or even their own time integrator.

Following an overview of our formulation of the Schwarz alternating method and its convergence properties, we will describe the method's implementation within two codes (Albany LCM [3], Sierra/SM[4]) and demonstrate the method's accuracy, convergence and scalability on a number of numerical examples, including a realistic scenario involving the simulation of a bolted joint subjected to dynamic loading. These examples demonstrate that the method converges to the correct solution and is free of numerical artifacts (e.g., spurious reflection or refraction of waves) for a wide range of quasistatic and dynamic solid mechanics problems. Additionally, our results show that, despite its iterative nature, the Schwarz alternating method can actually lead to a reduction in the computational time relative to a single-domain simulation having a comparable resolution.

Time-permitting, we will outline a recently-started research effort focused on developing a Schwarz-like algorithm to address several known challenges in the numerical simulation of mechanical contact, namely the accuracy of enforcement of the contact constraint and the multiple scales involved.

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", *Comput. Meth. Appl. Mech. Engng.* (under review).

[3] A. Salinger, R. Bartlett, A. Bradley, Q. Chen, I. Demeshko, X. Gao, G. Hansen, A. Mota, R. Muller, E. Nielsen, J. Ostien, R. Pawlowski, M. Perego, E. Phipps, W. Sun, I. Tezaur. "Albany: Using Agile Components to Develop a Flexible, Generic Multiphysics Analysis Code", *Int. J. Multiscale Comput. Engng* 14(4) (2016) 415-438.

[4] SIERRA Solid Mechanics Team. Sierra/SolidMechanics 4.48 User's Guide. Tech. rep. SAND2018-2961. Sandia National Laboratories Report, Oct. 2018.