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Monolithic multitime-step coupling methods for transient problems in solid mechanics and transport

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ABSTRACT

Developing computational frameworks for transient interaction-type problems (e.g. fluid–structure interaction, thermal–structure interaction) has been an active area of research in the past few decades. Computer simulation of such systems is extremely important in state-of-the-art science and engineering applications. Coupled problems often feature disparate temporal and spatial scales due to the presence of different physical phenomena. Hence, a desirable numerical framework should be able to facilitate different numerical formulations, different time-integrators, and time-steps in different regions of the computational domain. However, till date, no comprehensive numerical framework exists. Many of the coupling methods suffer from stability and convergence issues. Some other common drawbacks are limitation on the number of subdomains, time-steps, and preferential treatment of subdomains. In this presentation, we shall take a theoretical point of view (based on theory of differential/algebraic equations) toward coupled problems. We shall shed light on the cause of deficiencies in some of the earlier notable works. The proposed multitime-step coupling method [1] allows arbitrary number of subdomains, different finite element formulations, and different time-integrators and time-steps in different spatial regions. A comprehensive theoretical study of this method (which includes stability, influence of perturbations, bound on drifts, accuracy, and numerical energy dissipation properties) will be presented. Several numerical examples ranging from simple test problems to elastodynamics and advective–diffusive–reactive systems will be presented. These problems will provide a valuable insight into attractive features of the proposed method and will showcase its performance.

REFERENCE

[1] Karimi, S. Nakshatrala, K.B. *On Multi-time-step Monolithic Coupling Algorithms for Elastodynamics*. arXiv:1305.6355, 2013.