Co-simulation of Mechanical Systems in Non-smooth Problems

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ABSTRACT

Many physical systems can be modelled as a collection of various types of subsystems, such as mechanical, hydraulic, and electronic, which represent different physical domains. Our main focus is when the mechanical system gives the main subsystem.

For example, this is the case for most types of machinery, vehicles, and robots. The mechanical subsystem then needs to interface other domains, such as hydraulics, thermo-fluidics, and electronics. The modelling of the operation of such systems generally requires non-smooth system models that consider unilateral interactions, and include impact and friction. It is possible to show that generally only first-order time stepping methods can solve such problems.

We particularly consider non-iterative co-simulation. In such a setting the time stepping of each subsystem is processed separately with possibly different steps, and coupling variables are exchanged at discrete communication time points. This is also the technique that can be used for interactive and real-time simulations. The main issue with this approach is generally stability; the larger the communication step size is the more likely that the system becomes unstable.

Our proposed approach to increase the stability region relies on the use of reduced-order models of the mechanical system to interface the subsystems of other domains that will likely use a time step smaller than that of the mechanical system.

This model-assisted method creates a more systematic and accurate approach compared to extrapolation techniques. We will describe the main concepts in this presentation, and illustrate the results using interfacing mechanical and hydraulic subsystems.