Time Adaptivity for Optimal Control of Nonlinear Fluid-Structure Interaction

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Abstract: In this talk we consider time adaptivity for optimal control of variational-monolithic fluid-structure interaction.

In the regarded fluid-structure interaction system, the isothermal, incompressible Navier-Stokes equations are coupled with nonlinear elasticity. The former system is of parabolic type and describes fluid flow, whereas the latter equation serves for a solid description and is of hyperbolic character. To determine unknown material parameters and artificial boundary information, as well as to influence the highly dynamic system, we solve an optimization problem subjected by the fluid-structure interaction system. Possible applications range from aeroelasticity, over mechanical engineering, up to computational medicine and medical engineering.

As the Navier-Stokes equations are of parabolic type and the solid equations of hyperbolic nature, they ask for different conservation properties that should be reflected in their temporal discretization. To circumvent this difficulty and to improve the convergence of the optimization algorithm we use a dual-weighted residual error estimator for a fractional-step-theta time-stepping scheme. The algorithm for temporal adaptivity is based on a Galerkin interpretation of the fractional-step-theta time-stepping scheme and a rigorous derivation of dual-weighted sensitivity measures. All developments are substantiated with several numerical tests that include FSI-benchmarks with appropriate extensions and a flapping membrane example. Furthermore we take a closer look on optimal control of these configurations.

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