Space-time goal-oriented error control and adaptivity for discretizations and reduced order modeling of multiphysics problems

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Abstract

In this thesis, we investigate the use of adaptive methods for the efficient solution of linear multiphysics problems and nonlinear coupled problems. The main ingredients are a posteriori error estimates based on the dual-weighted residual method. By solving an auxiliary adjoint problem, these error estimates can be used to compute local error indicators for spatial and temporal refinements, which can be used for adaptive spatial and temporal meshes for e.g. the Navier-Stokes equations. For interface- and volume-coupled problems, we present a further extension of temporal adaptivity by using different temporal meshes for each subproblem while still being able to assemble the linear system in a monolithic fashion. Since multiphysics problems, like poroelasticity, are expensive to solve for fine discretizations with millions of degrees of freedom, we present a novel online-adaptive model order reduction method called MORe DWR (Model Order Reduction with Dual-Weighted Residual error estimates), which merges classical proper orthogonal decomposition based model order reduction with a posteriori error estimates. Thus, we can avoid the costly offline phase of classical model order reduction methods and still achieve high accuracy by enriching the reduced basis on-the-fly in the online phase when the error estimators exceed a given tolerance.

Keywords: multiphysics, tensor-product space-time finite elements, goal-oriented error control, dual-weighted residuals, mesh adaptivity, multirate, incremental proper orthogonal decomposition, model order reduction.