Adaptive Simulation of Multiphysics Problems

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In this talk we outline a basic framework for adaptive simulation of multiphysics problems. We assume that we have access to solvers for the different kinds of physics in the problem. A multiphysics solver can then be obtained by letting these solvers communicate in a network. This situation is typical in industrial and lab environments where efficient solvers with detailed modeling of certain physical phenomena have been developed over the years. These solvers are then combined in multiphysics simulations.

We develop a basic a posteriori error analysis for such networks of solvers (c.f., [1]). We assume that each solver is adaptive and supports duality based a posteriori estimates for the error in linear functionals of the solution. The error in the functional is basically estimated by terms accounting for the discretization of the problem and the error in data to the problem. The discretization error is controlled using standard adaptive mesh refinement based on the a posteriori error analysis. The data error can account for uncertainty in given data or may depend on another solver. In the latter case the data error can be controlled by sufficient accurate solution of that problem. This dependency between the problems in the network is captured and quantified by solving a specific sequence of dual problems.

The basic theory is illustrated on some examples including solution of the pressure equation together with the transport equation with applications to oil reservoir simulation and the heat equation coupled with linear elasticity with application to stresses caused by heat in gearbox casings.

References

1. Målqvist, A., Adaptive Variational Multiscale Methods, PhD thesis, Chalmers University of Technology, 2005, ISBN 91-7291-654-0.