Multigrid for multiphysics using the MueLu framework

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ABSTRACT

Computer simulations of multiphysics problems not only grow in size but also in complexity including more and more types of physics and coupling equations. Multi-physics systems are typically characterized by multi-scale temporal and spatial mechanisms and therefore often demand implicit solution methods.

Multigrid methods are known to be efficient preconditioners or solvers for linear systems arising from certain classes of single-field problems. However, the design and handling of fully coupled physics-based multigrid preconditioners for multiphysics problems remains a challenge.

MueLu [1] provides a flexible multigrid framework in Trilinos to build application-specific block preconditioners based on algebraic multigrid methods. We demonstrate the design principles and usage of the MueLu framework for different multiphysics problems including MHD [2] and structural contact mechanics problems [3, 4]. A special focus will be on the construction of physics-based block smoothers that are used for the coupling of the different physical and mathematical fields.

Finally, we compare the performance of the multigrid preconditioners with alternative preconditioning methods.

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