Implementation of hp-adaptive FEM in HiFlow3

Staffan Ronnas[1] Martin Baumann[2]

The finite element method is popular among scientists and engineers who need to solve PDEs and integral equations arising from problems in a large number of areas. As the complexity of models being solved using FEM increases, the need for adaptive algorithms that can construct accurate approximations using a small number of degrees of freedom becomes apparent. At the same time, the use of high-performance parallel computing on distributed-memory machines remains necessary to be able to tackle many problems.

hp-adaptivity is one of the most powerful approaches to adaptive finite element discretization. By combining local mesh refinements close to irregularities of the solution with the use of higher-order elements where the solution is smooth, this technique often yields very high convergence rates and reduces the computation time significantly.

In this talk, we will present some aspects of how support for parallel hp-adaptivity was implemented in HiFlow3, a general purpose C++ library designed to assist in the construction of parallel finite element solvers.

Of primary importance is the support for different cell types and refinement strategies in both conforming and non-conforming meshes, which forms the basis for adaptation of the discretization space. Another central issue is the numbering of degrees of freedom, and the identification of additional constraints in the presence of hanging nodes and local variations of polynomial orders. Finally, the use of parallel data structures for representing the computational mesh makes it possible for algorithms to scale to a large number of processors, without being limited by memory constraints.

[1] Institute for Applied and Numerical Mathematics 4, Karlsruhe Institute of Technology, staffan.ronnas@student.kit.edu

[2] Institute for Applied and Numerical Mathematics 4, Karlsruhe Institute of Technology, martin.baumann@kit.edu