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Parallel Multigrid Preconditionner based on Automatic 3D Tetraedric Meshes

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Multigrid methods are efficient for solving large sparse linear systems. Geometric (GMG) and Algebraic Multigrid (AMG) have both their own benefits and limitations. Combining the simplicity of AMG with the efficiency of GMG lead us to the development of an Hybrid Multigrid preconditionner. From an initial fine mesh we first build coarser unnested meshes and then deduce interpolation and restriction matrices based on interpolation of a mesh into a coarser one. We finally use Galerkin relation on each level to create our coarser problem matrix.

We focus on the resolution of linear systems coming from solid mechanics problems. More specifically we solve Stokes problem using a 3D tetraedric mixed finite element formulation (P1+/P1) leading to a specific kind of problem with the associated matrix [1]. To deal with complex geometries and various material forming processes, we use unstructured mesh and need the resolution method to be compatible with automatic remeshing. Coarser meshes, interpolation and restriction operators and coarser matrices have then to be automatically built and rebuilt.

As nowadays numerical simulations can not ignore the evolution of computer architecture, our developments take parallel computing into account. We manage to create well-balanced partitions and generate coarser meshes with a similar partitioning, so that the communication costs are minimized. The matrices (interpolation, restriction, coarser problems) are computed in parallel and the resolution uses smoothers and coarse grid solver suitable for parallel computations.

[1] T. Coupez, S. Marie, From a direct solver to a parallel iterative solver in 3-D forming simulation, International Journal of High Performance Computing Applications (1997) 11: 277-285.