A Metric-based Adaptive Mesh Refinement method for elliptic multigrid solvers based on quadtree/octree grids

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In this work we present a new adaptive mesh refinement (AMR) method implemented in our in-house open-source solver Basilisk [1,3]. The solver uses a cell-centered approach for the numerical resolution on isotropic octree/quadtree meshes. This AMR method aims at improving the accuracy of numerical solutions of problems with multiple scales.

The new AMR approach uses a metric-based linear interpolation error estimation [2] coupled with a solver-based error model without the need to solve a dual problem. It is shown that for some problems, the grid obtained from the solution of a minimization problem for the (local) interpolation error does not minimize the error introduced by a numerical solver. By imposing an additional constraint on the cell size ratio between the largest and minimum cell the results are significantly improved reducing the error introduced in the solution for a constant number of grid points. We develop an automatic algorithm able to obtain the additional cell-size ratio constrain from the multigrid structure of octrees/quadtrees. The performance of the proposed algorithm provides results close to the optimal performance expected for quadtree/octree grids.

The performance of our new approach is validated on a Poisson-Helmholtz solver and an incompressible Euler solver through problems with known solutions. These problems, with diverse level of complexity, are shown to be challenging test cases to evaluate the efficiency of AMR methods.

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