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ANISOTROPIC ADAPTIVE FINITE ELEMENT MESHES FOR INCOMPRESSIBLE FLOWS

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Abstract. Because of the increasingly complex geometries involved in flow problems of industrial relevance, numerical methods based on unstructured meshes have become popular in CFD. However, the corresponding meshing methods require a high-quality CAD description of the geometry, which is not part of the traditional workflow in fields like architecture or medicine. Many professionals also lack the expertise required to build appropriate meshes for flow problems. Nevertheless, recent progresses in meshing technology could overcome these barriers.

In this talk, we propose to use anisotropic adaption to generate a *nearly* body-fitted mesh. The mesh is locally refined depending on a level-set function that describes the geometry without resorting to a CAD model. Dirichlet boundary conditions can then be imposed in a strong manner by node collocation, just as with classical body-fitted meshes. Unlike other treatments of embedded geometries, this technique only requires a standard finite element formulation, without basis enrichement or Lagrange multipliers that alter its numerical properties.

In a first step, we apply this method to academic Poisson problems. We show that an appropriate level of local refinement around the geometry recovers the optimal grid convergence rate for the solution, whereas uniform refinement yields first-order convergence. Controlling the anisotropic character of the adaption further enables the error of the geometrical discretization to decrease at optimal rate, while there is no geometrical convergence with isotropic refinement. This affects particularly the computation of integral

quantities, such as lift and drag, in practical simulations. Anisotropic adaptive refinement also slows down the growth of the number of unknowns, which limits the computational overhead.

Then, we combine the embedded geometry treatment with iterative anisotropic adaption to the solution, for two incompressible flow problems involving respectively a cylinder and a NACA0012 airfoil. The methodology yields accurate flow solutions, despite very limited user interaction.

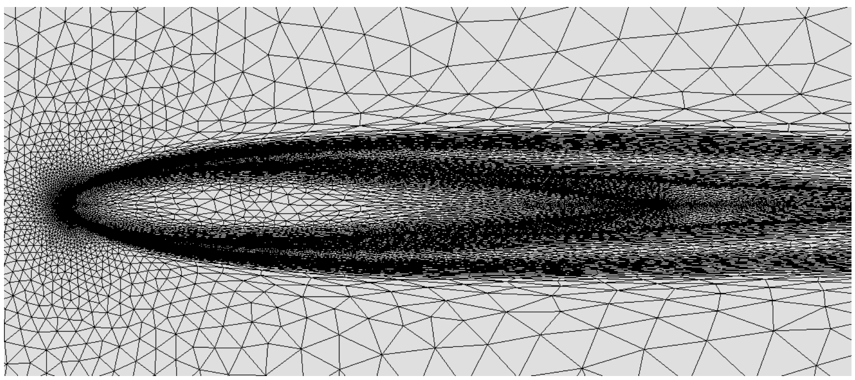

Figure 1: Anisotropic mesh adapted to the geometry and to the solution for the non-lifting incompressible flow around a NACA0012 airfoil at Reynolds number 5000.