11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

RESIDUAL SCHEMES FOR PENALIZED NAVIER-STOKES EQUATIONS ON ADAPTED GRIDS

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Key words: *Residual schemes, Immersed Boundary Method, Penalization, Unstructured grids, Mesh adaptation.*

The interest on embedded boundary methods increases in Computational Fluid Dynamics because they simplify the mesh generation problem when dealing with the Navier-Stokes equations. The same simplifications occur for the simulation of multi-physics flows, the coupling of fluid-solid interactions in situation of large motions or deformations, to give a few examples. Nevertheless an accurate treatment of the wall boundary conditions remains an issue of the method. In this work [1], the wall boundary conditions are easily taken into account through a penalization technique applied to the Navier-Stokes equations, and the accuracy of the method is recovered using mesh adaptation, thanks to the potential of unstructured meshes. The solids around which the flow is computed are defined using the so-called penalization method or Brinckman-Navier-Stokes equations. Here, the solids are considered as porous media with a very small intrinsic permeability. The idea is to extend the velocity field inside the solid body and to solve the flow equations with a penalization term to enforce rigid motion inside the solid. A level set function, the sign distance function to the solids, is used to capture interfaces of the solid bodies.

Our numerical simulations are performed on unstructured meshes (2D-triangles or 3D-tetrahedrons). The system of equations is discretized using residual distribution schemes [2].Those numerical schemes allow to construct a high order method with compact stencil to ease parallelism. In this work, we propose to combine our level set based immersed boundary approach to mesh adaption. The idea is to conserve the simplicity of the embedded approaches for grid generation process and overcome the difficulty of wall treatments by using mesh adaptation. Mesh adaptions are performed using two criteria, the distance to the level-set 0 and the velocity component of the flow solution. Using some test cases we demonstrate the ability of the proposed method to obtain an accurate solution along with an accurate wall treatment even when the initial mesh does not contain any point on the level-set 0. For example we consider the supersonic flow around a solid body of triangular shape. The same computational domain as [3] is chosen and the computation is stopped when a steady state is obtained. As in Boiron *et al.* [3] an oblique shock is predicted and attached to the triangle, see figure 1. Our results are in good agreement with the theory and the numerical solutions performed in [3].

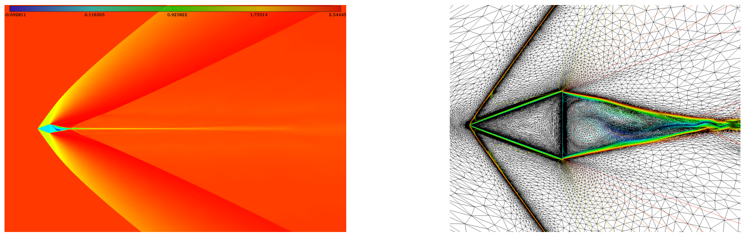

Figure 1: Velocity on the adapted mesh

Further investigations are performed to deal with moving bodies. The first step consists in following the moving body with the adapted grid. Two different approaches can be studied, the first one consists in solving the advection equation which governs the level-set evolution and the second one computes the whole signed distance function on the mesh after each displacement. A combination of both approaches will be studied to choose the best compromise between cpu time and quality of the solution. Figure 2 presents the displacement (rotation + translation) of a 3D quadrangle and a 2D Naca airfoil.

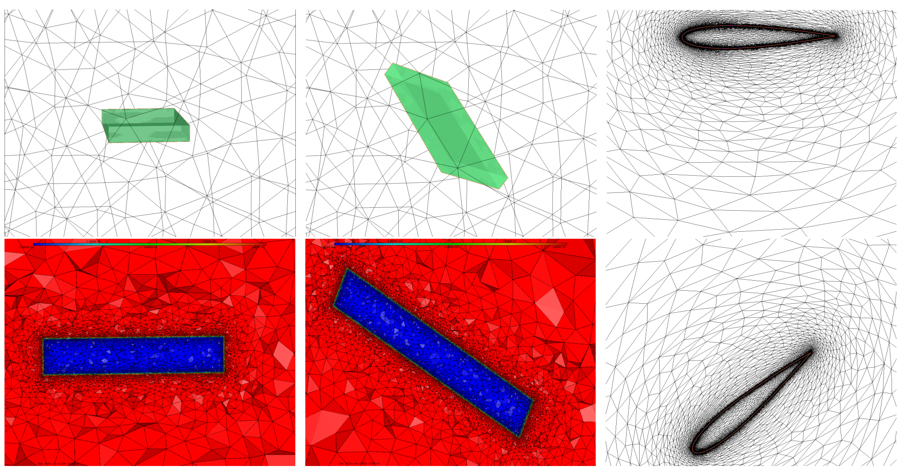

Figure 2: Left : Moving quadrangle, Top : 0 isosurface, Bottom : Mesh cut with level-set; Right Oscilating Naca Airfoil, Top : Initial mesh and 0 level-set, Bottom : Final mesh and 0 level-set

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