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# *NEARLY* BODY-FITTED MESHES FOR TRANSIENT FLOWS WITH EMBEDDED GEOMETRIES

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Embedded geometries involved in flow problems have been studied increasingly in the recent years. Different approaches have been used, such as the extended finite element method, fictitious domain methods or Nitsche's method. Nevertheless, such methods require deep modifications in the finite element kernels in order to weakly impose boundary conditions on the non-fitted mesh. Some of them also suffer from stability issues.

In our method, a *nearly* body-fitted mesh approach is proposed for solving problems with embedded geometries. The proposed adaptive strategy for CFD consists in modeling an embedded interface $\Gamma$ by a level-set representation in combination with local anisotropic mesh refinement in the vicinity of $\Gamma$. Unlike other treatments of embedded geometries, boundary conditions are imposed in a strong manner on $\Gamma^*$, which is the approximate representation of $\Gamma$ by the mesh. This technique only requires a standard finite element method, without resorting to basis enrichment or Lagrange multipliers to prescribe boundary conditions.

Optimal convergence rates have been shown to be recovered for both academic Poisson problems and Navier-Stokes equations. In addition, other integral quantities over the interface, such as lift and drag coefficients, can be obtained with satisfying accuracy [1, 2].

In this work, the *nearly* body-fitted approach is employed in combination with iterative mesh adaptation to the flow solution. For time-dependent flow problems in particular, we use the transient mesh adaptation scheme introduced in [3]: in a predictor step, the flow is computed throughout a given time period, and the error is estimated a posteriori at several time points within this period. The mesh is then adapted according to a criterion combining the whole set of error estimations, and a more accurate flow computation is carried out for the time period.

In this talk, we will illustrate our methodology with several application examples, such as the transient flow over a 2D cylinder at $Re = 100$ shown in Figure 1 or the bypassed artery geometry represented in Figure 2.

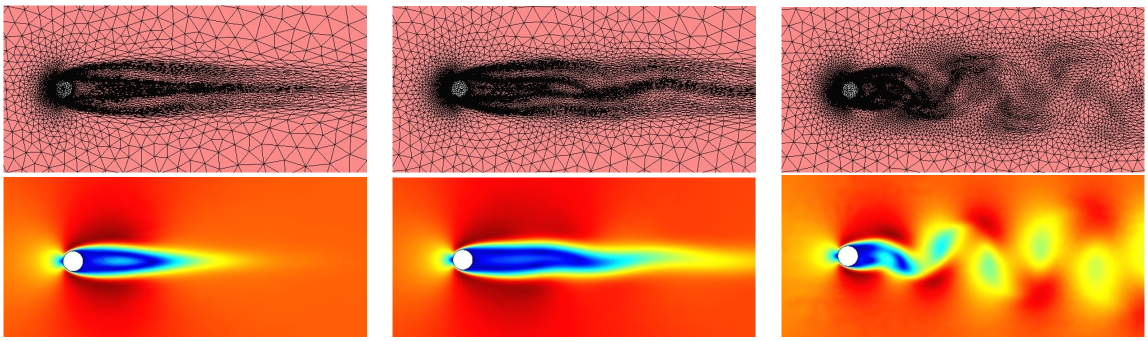

Figure 1: Transient mesh adaptation and visualization of corresponding solution for flow over 2D cylinder at $Re = 100$.

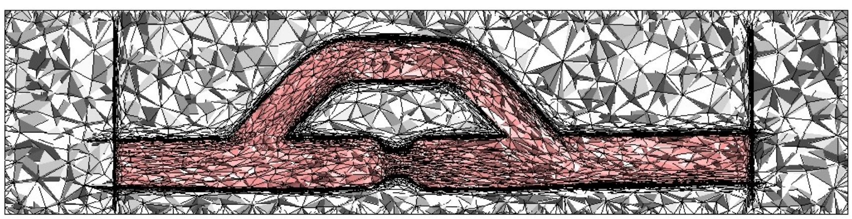

Figure 2: Anisotropic mesh adapted to the geometry and to the solution for blood flow through a bypassed artery at Reynolds number $Re = 500$.

## REFERENCES


[1] D.-L. Quan, T. Toulorge, E. Marchandise, J.-F. Remacle and G. Bricteux. Anisotropic mesh adaptation with optimal convergence for finite elemetns using embedded geometries. *Computer Methods in Applied Mechanics and Engineering*, Vol. **268**, 65–81, 2014.

[2] D.-L. Quan, T. Toulorge, G. Bricteux, J.-F. Remacle and E. Marchandise. Anisotropic adaptive nearly body-fitted meshes for CFD. *submitted to Engineering with Computers*, 2013.

[3] F. Alauzet, P. L. George, B. Mohammadi, P. Frey and H. Borouchaki. Transient fixed point-based unstructured mesh adaptation. *International Journal for Numerical Methods in Fluids*, Vol. **43**, 729–745, 2003.