Higher order evaluation of hydrodynamic stresses on immersed body surface *

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The Immersed Boundary Method (IBM) has proven to be a valuable tool for the investigation of fluid-structure interaction due to its capability of dealing with complex geometries and deformable bodies. In particular, the IBM - Moving Least Squares (IBM-MLS) formulation exploits MLS transfer functions [1] to interpolate flow quantities from the Eulerian grid to the Lagrangian markers and fulfil the no slip condition on the body wet surface. The IBM-MLS is particularly suited in Fluid Structure Interaction (FSI), since the flow field is smooth around the body.
However, the evaluation of hydrodynamic forces acting on the surface is non-trivial, since the Eulerian grid is non-conformal. Several techniques have been proposed to evaluate the fluid loads with high precision, such as the Hydrodynamic Stress Model [2] (HSM), that employs a wall function to reconstruct the flow field in the wall vicinity, exploiting the laminar boundary layer approximation.
In our work, we propose a different field reconstruction technique that does not rely on any assumption on the subgrid flow reconstruction: the velocity and pressure fields are reconstructed near the wall exploiting the Taylor series expansion of velocity $\mathbf{u}$ and pressure p on the Eulerian grid. Then, the MLS basis functions are employed to transfer the stress tensor from the Eulerian grid to the Lagrangian markers, where the hydrodynamic stress is evaluated. The model increases the accuracy of the loads evaluation at a reduced overhead on each time step and provides smooth forces on the surface thanks to the MLS interpolation.
Our approach is tested in a series of benchmark flows, including fixed and moving rigid bodies. The proposed model is not limited to IBM-MLS but can be applied to any IB method.

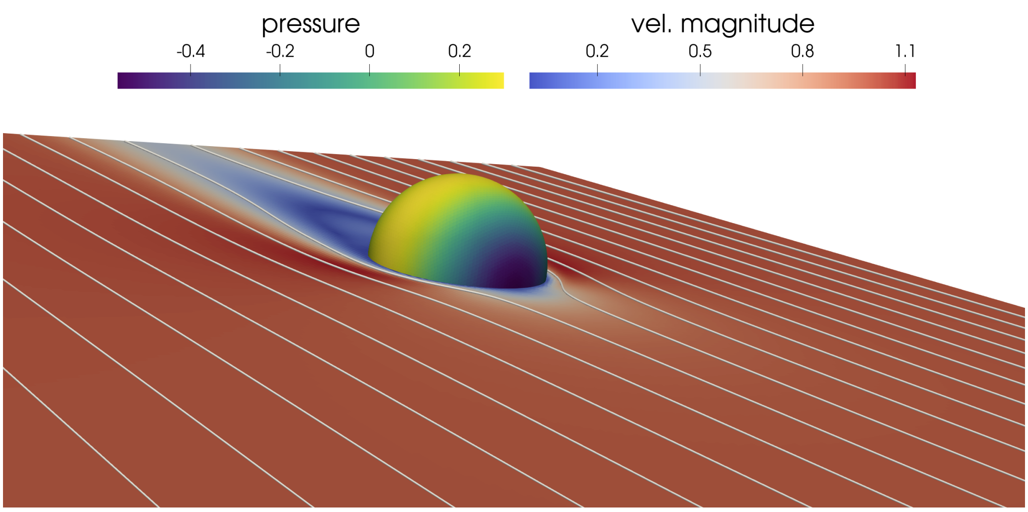

Figure 1: Flow around a fixed sphere at $Re = 100$. The planar section shows the velocity magnitude with superimposed the velocity streamlines. The isocontours on the sphere show the surface pressure exerted by the flow.

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