Geometric Immersed Boundaries (GIB): A New framework for applying boundary conditions in Finite Volume Method

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In this paper, a novel method for applying boundary conditions in finite volume method, is presented. In this new framework, standard boundary conditions (Diriclet, Neumann etc.) can be applied on new immersed boundaries which are constructed from existing internal faces and produce identical results to the standard boundaries.

This methodology is powerful in applications with moving parts such as topology optimization, rotating gears, FSI, etc. Currently, in these applications, the mesh motion algorithm moves the boundaries until re-meshing is required. This method, in most industrial applications, is inefficient or unfeasible. Using GIB, the point coordinates of the faces near the interface are snapped on the interface. After the snapping, a group of faces which are located exactly on the interface, is constructed. A new boundary is created based on the interface and boundary conditions are applied. The matrix contributions of each implicit and explicit finite volume operator using GIB and body fitted meshes are the same which guarantees that the results will be identical. The implementation is generic and no additional numerical schemes or executables are required. The method has been developed in the opensource CFD software OpenFOAM®.

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I. Results

In this section static and moving immersed boundaries are benchmarked with a body fitted mesh.

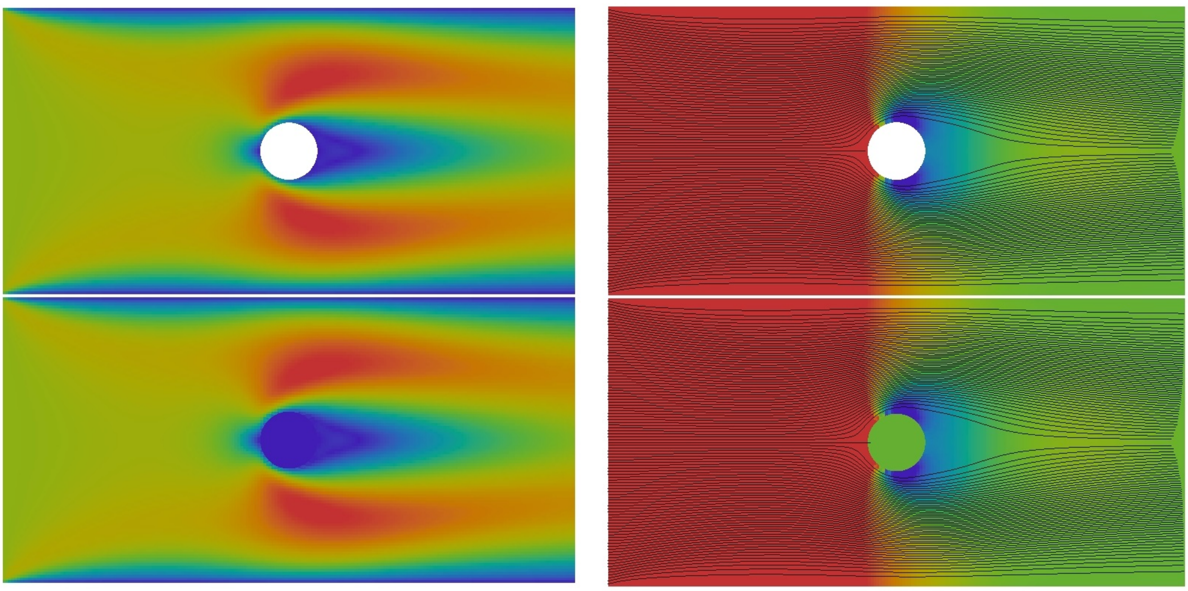

Figure 1: Velocity (left) and pressure (right) fields around a cylinder with classic boundaries (top) and the GIB (bottom). The results in the immersed boundaries case are identical with the bodyfitted approach.

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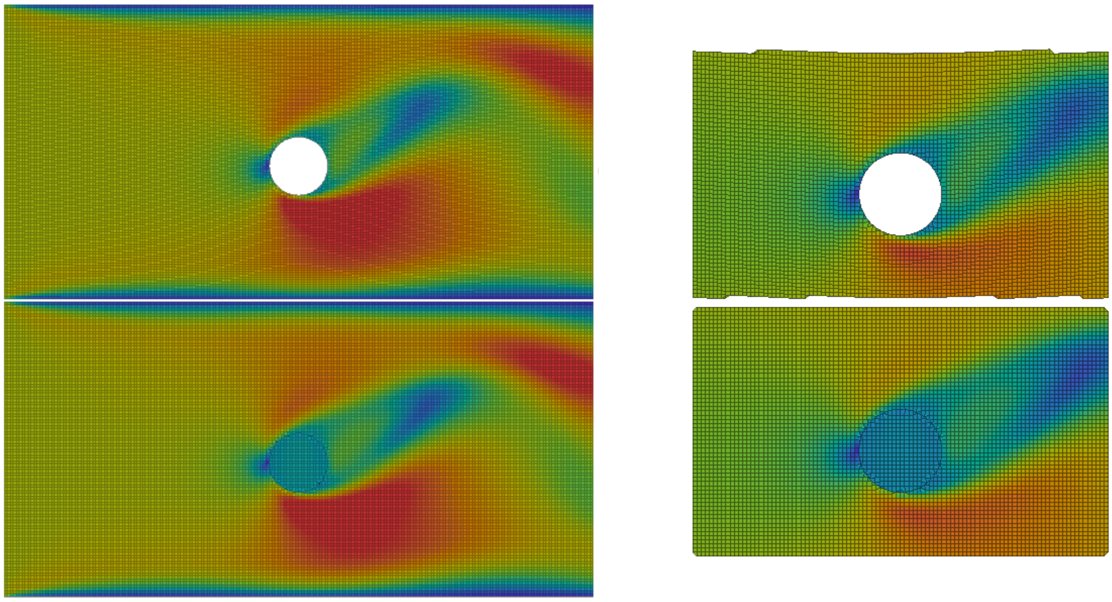

Figure 2: Velocity field around a moving cylinder with classic boundaries (top) and the GIB (bottom).

References

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