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CONSERVATIVE CUT-CELL DISCRETIZATION FOR VISCOUS INCOMPRESSIBLE FLOW

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The computation of viscous incompressible flows around objects, like the air flow through a wind farm, is our interest. These flows are most accurately modelled by using object-fitted meshes. However, if multiple asynchronously moving objects are present in the flow the use of object-fitted meshes becomes very expensive because every object needs its own mesh and every time-step requires interpolation between the different meshes. For the simulation of a wind farm the resulting computational costs of this approach are too high and a different approach must be used.

An efficient alternative is to use only one stationary Cartesian mesh through which the objects move. However, to take into account the no-slip boundary conditions on the objects, the discretization has to be adjusted in the cut cells.

A very popular discretization method for viscous incompressible flow is the MAC scheme [1]. In the MAC scheme the velocity variables are located on the cell faces and the pressure variables are located in the cell centers. This staggered variable positioning leads to a very efficient method that conserves mass, momentum and energy (in the absence of viscosity), and as such is very suitable for modelling turbulent flows. However, the staggered positioning of the variables complicates an extension of the method to arbitrarily shaped cut cells.

In this paper we present an extension of the MAC scheme to 3D cut-cell meshes. We show that the extension still has many of the favorable conservation properties of the original MAC scheme, and, moreover, is easily implemented. Furthermore, we study the extension of the method to time-dependent geometries. We will especially focus on the application of the method to wind farm aerodynamics. We present relevant 2D and 3D simulations.

REFERENCES

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