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SOLUTION-ADAPTIVE GRID RESOLUTION FOR FLUID STRUCTURE INTERACTION

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For many engineering problems the interaction between a moving structure and a turbulent flow is of importance. Numerical models are used to predict the behavior of such systems. The overall solution fidelity and efficiency strongly depends on the quality of the turbulent flow model which in turn strongly depends on the underlying spatial discretization. Using finite volumes, the grid resolution has to fulfill the turbulence model requirements for every state of flow induced by the moving structure. A common approach to cope with the deforming fluid domain is to use moving grids with an arbitrary Lagrange Euler formulation of the transport equations. Standard techniques for moving the grid points, like spring analogy methods or interpolation methods (see, for example [1, 2, 3]), are designed to keep the initial distribution constant relatively to the structure.

Large structural displacements, where the grid resolution requirements change, may produce wrong flow solutions. In this contribution we show that it is possible to meet the near wall resolution requirements of a RANS model in a generic test case by relocating grid-points according to the flow situation. The idea is that since it is necessary to solve a grid movement problem for the deforming domain anyway, also incorporate solution information for a more suited fluid grid. We use the target-matrix-paradigm introduced in [5] to formulate the grid movement problem as an optimization problem. This method considers an optimality defined as minimal skew for a desired size for each cell. To ensure normalized wall distance y+ values below one, cell sizes are scaled with a smoothed field of inverse values in each fluid-structure coupling step.

As generic test case a flat plate with a prescribed rotational movement in free flow is investigated. The angle of attack varies from 0 degree to 60 degree over time. The transient turbulent flow field is calculated with a V2F RANS model on a finite volume block-structured hexahedral mesh. Using transfinite interpolation [4] with a grid-point distribution fitted to the starting conditions as grid moving method leads to errors in the lift- and drag-coefficients. By employing the method described above it is possible to fulfill the near-wall resolution requirements within every time step and thereby getting more accurate aerodynamic coefficients.

This numerical experiment shows, that it is important to control the grid resolution for simulations with changing flow conditions as occurring for FSI scenarios. The grid moving strategy outlined here in principle is not restricted to just limiting y+. Other solution dependent criteria are possible as for example velocity gradients aiming to reduce discretization errors.

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