Reduced Order Modelling for Rotating 2D Cross-Section using Divergence-Conforming Isogeometric Navier-Stokes Solver

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ABSTRACT

Repetitive solutions of parametrized flow problems can be quite demanding, each solution involving a million or more degrees of freedom, that takes hours or days of computational time. A promising methodology to reduce the (on-line) computational effort is the use of Reduced Order Modelling (ROM). ROM offers the possibility to balance loss of accuracy with gain in efficiency, see [1].

We have tied ROM with a divergence-conforming isogeometric high-fidelity method for incompressible flow simulations and achieved (significant) additional speedup compared to non-conforming methods [2]. The additional speedup is related to less computations related to the supremizers needed for avoiding that the ROM model get a rank-deficient velocity-pressure block.

Our aim is that all the forms in the ROM-system may be expressed as linear combinations of forms, precomputed in the offline stage, that are parameter-independent. However, for the case of moving fluid boundaries, i.e. rotating 2D cross-section addressed herein, this is not straight forward due to the changes to the fluid domain. We have solved this by mapping the fluid problem for every angle of attach back to the initial configuration (i.e. zero angle of attach) and developed a Taylor series for the Jacobian mapping (we use Jacobian mapping in order to preserve the divergence-conforming property of our formulation) to achieve affinity.

We will illustrate the performance of the development method by doing high fidelity simulations of stationary Navier-Stokes were performed of flow around a NACA0015 airfoil cross-section where we vary the inflow velocity and the angle of attack.

REFERENCES

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