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The Effect of Flexible Flaps on the flow dynamics of a Stalled Airfoil

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Synopsis

The operational limit of Micro Aerial Vehicles (MAVs) can be extended by delaying flow separation using biomimetic methodology inspired by secondary covert feathers of a bird's wings that appear on the upper surface during high angle-of-attack maneuvers or sudden gusts. This is canonically modelled as a flexible flap on the upper surface of an airfoil in the present study. This study sets up a case for fluid-structure interaction (FSI) simulation of a flexible flap on the surface of a NACA0012 airfoil at an angle-of-attack of 45° and Reynolds Number of 1000. The present open-source FSI framework comprises a finite volume method based incompressible flow solver 'pimpleFoam' available in OpenFOAM, a finite element method based structural solver CalculiX, and a coupling platform preCICE. For the coupling of the fluid and the solid solvers, a parallel-implicit scheme is used with nearest neighbor mapping technique. Three different flap positions, 10% chord, 50% chord, and 90% chord, were studied. Among the three, comparing the mean drag coefficient ($\overline{C_d}$), flap at 90% chord was found the most aerodynamically efficient. However, to get the optimal position of the flap, a systematic study has to be conducted comparing various flap positions in terms of generated lift and mean lift-drag ratio, among others.