Simulation of compressible flows over opening wing-flap configurations through continuous boundary modification

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ABSTRACT

The simulation of fluid flows with topologically changing boundaries, like opening flaps or valves, poses several difficulties, both from the physical point of view (i.e. the necessity to handle the solution singularity in time) and the numerical point of view (the need for adaptive data structure). We simulate the opening of an airfoil flap by considering its continuous transformation from a single closed body to a hinged airfoil-flap configuration. This is done through a capillarity analogy, where the flap tip is connected to the wing through a fictitious deformable membrane which is pulled inside the opening gap as the flap angle is increased, in order to preserve the boundary continuity. Domain and boundary grid adaptation is performed at each time step, so to preserve grid quality throughout time. The simulation is performed through the Flowmesh flow solver[2] coupled[1] with the MMG remeshing library[3]. This formulation employs a continuous grid evolution approach, based on the interpretation of each local mesh modification (node insertion, deletion, edge/element split) as a continuous transformation of a grid element from null to finite volume (or viceversa), into an Arbitrary-Lagrangian Eulerian Finite Volume solver for compressible flow, thus capable of including dynamic mesh adaptivity without any explicit interpolation step.

The membrane is modeled as a 2D elastic solid, though an updated Lagrangian formulation, subject to a central force field designed to smoothly pull it inside the opening gap.

REFERENCES

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