A computational framework for evaluating the longitudinal trim of highly flexible aircraft

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Abstract. This work presents a novel computational framework for the longitudinal trim analysis of highly-flexible aircraft.

The framework enables the modelling of the non-linear aeroelastic response of highly-flexible lifting surfaces by means of a coupled solution of finite-strain elasticity and potential-flow aerodynamics.

The equations governing finite-strain elasticity are solved using the discontinuous Galerkin (DG) method, a numerical technique for solving partial differential equations that is based on a discontinuous representation of the solution and on the use of suitably-defined boundary integrals to enforce the continuity of the solution and the boundary conditions.

Owing to its discontinuous nature, the DG approach enables a variable-order accurate solution of the equations at hand regardless of the choice of the discretization space.

Potential-flow aerodynamics is solved by a non-planar Vortex Lattice Method (VLM), whereby the lifting surface is replaced by a collection of ring and horseshoe vortices, which can follow the deformation of the structure and allow evaluating the aerodynamic forces in the deformed configurations.

In addition, the framework allows modelling multiple lifting surfaces, a feature that is required to evaluate the trim conditions for an aircraft consisting of a main wing and a tail.

The accuracy and robustness of the proposed framework are assessed through the validation of three test cases: the finite-strain response of a cantilever beam, the non-linear aeroelastic response of a highly-flexible wing, and the determination of the angle of attack and elevator deflection corresponding to the longitudinal trim conditions of an aircraft featuring a highly-flexible wing.