High Fidelity Aeroelastic Analysis of a Membrane Wing

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Through aeroelastic modeling of membrane wings such as Leading Edge Inflatable (LEI) tube kites used in Airborne Wind applications, one can gain a better understanding of processes relevant for flight stability and performance optimization. The aim of this project is to establish a baseline for a partitioned aeroelastic solver suitable for membrane wings at high Reynolds numbers by coupling high fidelity structure and fluid models.

An in-house implementation of a dynamic, nonlinear Finite Element structural solver employing shell elements is used to model the canopy of the membrane wing [1]. As a first step, an unsteady lumped vortex particle method is used for the fluid model. Eventually the transient Navier-Stokes Finite Element solver Fluidity [2] is used to model the highly nonlinear flow around the membrane wing at high angles of attack present in crosswind flight of the kite.

The quantitative validation of the solver is initially done on the classical Fluid-Structure Benchmark case as proposed by Turek et al. [3]. Subsequently, a qualitative verification on the test case of Greenhalgh [4] as pictured on the left is carried out as well. While limitations in the experiment description make quantitative verification for this test case difficult, qualitative verification for steady inflow conditions at different angles of attack and hysteresis effects around an angle of attack close to zero are still possible.

While the benchmark cases of this project deliver proof of concept of the applied methodology, they are of little practical relevance. Nevertheless, in future projects the solver can be extended to include three-dimensional effects, a more realistic wing design and unsteady boundary conditions.

References:


