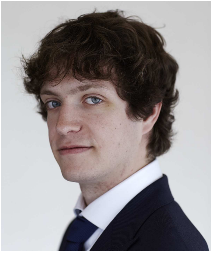
Mutiny/TU Delft V2 Leading Edge Inflatable tube kite finite-element model.



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Dynamic Nonlinear Aeroelastic Behaviour of Flexible Wings in an Airflow

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In the development of pumping cycle based airborne wind energy systems, the usage of kites has been a popular choice. In order to improve the efficiency and controllability of the kite, its design needs to be optimized for power generation. These days, kite designs originate from kite-surfing or paragliding. Here safety is the driving design criterion. Therefore it is expected that a redesign for energy generation will yield an improved efficiency of the kite power system. In order to perform this redesign, the flight behaviour of the kite needs to be investigated.

This research project builds on previously existing work [1,2,3] in an effort to develop a fluid-structure interactions model that is able to simulate the behaviour of the kite in flight. As this is a very complex task, the analysis tool that is developed in this project is focussed on the local deformation behaviour of this wing when it is suspended in an airflow. The tool is able to capture both the dynamic and the static nonlinear aeroelastic behaviour of the wing at reasonable computation speed.

As the nonlinear aeroelastic behaviour is a very complex and time consuming problem to solve, the algorithm used separates this model from the dynamic flight simulation. A linear simulation is used to simulate this in-flight behaviour. At discrete intervals this linear simulation is corrected using a nonlinear aeroelastic model. This leads to a significant reduction in computational requirements as the nonlinear aeroelastic problem is solved for a limited number of iterations, while it leads to an acceptable level of accuracy for the description of the dynamic behaviour of the kite.

For the structural modelling of the wing, a previously developed finite element solver is used [1]. This solver uses triangular shell elements to describe the wing structure. It allows for application of different aerodynamic load models. For the purpose of this project the wing is modelled using only these elements, while previously a complete LEI structure was modelled [1]. The applied aerodynamic model [2] is a correlation model that relates a minimum set of parameters to come up with an estimate of the aerodynamic load. The validity of this model is limited but the load estimation can be straightforwardly replaced by a different method for modelling the aerodynamics.

In this project the existing work on aeroelastic modelling was extensively verified. It provides with a good backbone for further research into fluid-structure interactions for kites or other flexible membrane wings because of the modular design philosophy.

References:
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