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Open-Source Parametric Finite-Element Meshing Tool for Fixed-Wing AWE Kites

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To reach a power production of multiple megawatts, AWE systems are required to grow considerably larger in size. Over 60% of the global warming potential (GWP) of a fixed-wing kite is due to carbon fibre reinforced polymers [1]. A lower GWP of materials is indispensable in scaling-up of AWE systems. Soft-wing kites have the benefit that the added volume is mostly extra air entrapped within the flexible membrane structure. However, for fixed-wing kites, increasing the dimensions leads to a substantially stronger increase in mass, which negatively affects the power output of larger AWE systems. Therefore, a higher fidelity structural model is required to better estimate and reduce the mass in the conceptional design phase of the system and study the viability of using more environmentally attractive materials.

Finite element (FE) modeling is considered a high-fidelity structural modeling approach and can potentially require many hours of design work to implement. The framework presented here is intended to be used as an open-source fixed-wing kite meshing tool, capable of creating an FE mesh from a set of common AWE system design parameters within seconds. This framework is also well suited for structural layout optimization studies. The parametric FE meshing and weight prediction capabilities are validated against the Ampyx Power AP3 remote piloted aircraft and compared to a tapered beam model, commonly used in conceptual design studies. In turn, an improved detailed reference kite progressing from MegAWES [2] can be designed. Future application of the tool will include studying the effects of design changes and the use of more environmentally attractive materials on a pre-determined set of structural failure criteria and fatigue behavior.

The tool chain couples Matlab with GMSH, an open source three-dimensional finite element mesh generator. A list of parameters is thereby converted into a FE mesh. Simcenter Nastran, a commercial structural solver from Siemens, is then called for structural analysis. The tool chain can also support other solvers, however, in this instance Simcenter Nastran was chosen due to the high degree of reliability.

References:

[1] L. van Hagen, Life Cycle Assessment of Multi-Megawatt Airborne Wind Energy, Master's thesis, Delft University of Technology, 2021.

[2] D. Eijkelhof, S. Rapp, U. Fasel, M. Gaunaa, R. Schmehl, Reference design and simulation framework of a multi-megawatt airborne wind energy system, Journal of Physics: Conference Series 1618 (2020) 032020. doi:10.1088/1742-6596/1618/3/032020.

Example of a quadrilateral mesh of the wing tip section generated from the MegAWES [2] reference kite (colorized for illustrative purposes).