Kite Electrical Energy Production

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Wind turbines are currently the only means to convert wind energy into electricity, but they are far from flawless: they require a significant amount of material, and transporting the components to the construction site is becoming increasingly challenging with their growing size. Kite sails address these two problems, as electricity production would require up to 90% less material for the same amount of energy produced, and as the absence of long rigid components makes transportation easy enough to relocate energy generation as needed. The size of wind turbines is limited by the transport of rigid components, whereas a kite sail only needs longer lines to fly higher; this allows to benefit from higher-altitude winds that are stronger and more consistent. However, the kite needs a control that keeps it airborne and maximizes the energy output. The objective of the KEEP (Kite Electric Energy Production) project, driven by ENSTA Bretagne in collaboration with Université Côte d'Azur, is to simulate the system by emulating the control thanks to a geometrical constraint, and to perform an optimization on the model parameters in order to obtain an initial estimate of the electricity production. The initial model is a system of second-order ODEs with five variables under three algebraic constraints. The coefficients of this ODE are calculated using automatic differentiation. Currently, no control is applied to the kite, but we can simulate its frictionless movement on a manifold defining conical constraints. We have demonstrated that we can simplify the initial model to a system of second-order ODE in dimension two, without algebraic constraints. Thanks to this simplification, we expect a reduction in computation times and more precise results. Once the new model is implemented, we will seek to maximize electricity production for a given integration time. This will be achieved by adjusting the model parameters under the constraint that the lines remain below a certain force level [1].

[1] K. Desenclos, A. Nême, J.B. Leroux, C. Jochum, A novel composite modelling approach for woven fabric structures applied to leading edge inflatable kites, Mechanics of Composite Materials, Volume 58, issue 6, (2023)