A Preliminary Estimation of the Absolute Wind Vector in AWE Systems

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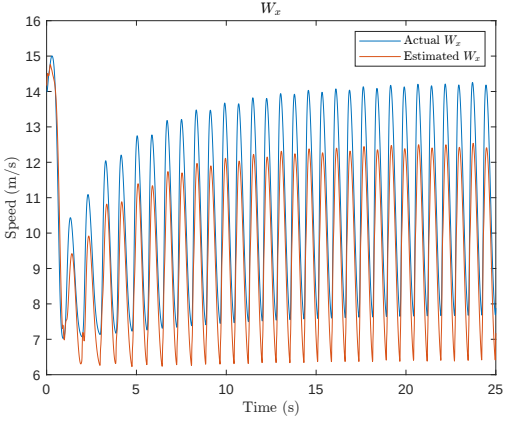
An accurate estimation of the wind vector at operational height is essential for the design, control, and optimization of AWE systems. However, the nonlinear and stochastic nature of altitude wind, the limited and noisy measurements from the onboard sensors, together with the complex aerodynamics of a tethered aircraft pose serious challenges to the task.

Inspired by an initial work at Kitemill [1], the main objective of this work is to develop and evaluate novel methods for wind speed estimation for AWE systems in a simulation setting. This paper proposes and compares two different approaches for wind vector estimation, without using any dedicated wind sensors and exploiting only the measurement of dynamical quantities of the kite. Under the assumption of perfect knowledge of the simulation model, the first approach utilizes a solver capable of handling nonlinear equations, minimizing the difference between the measured derivatives of the state and the estimated derivatives of the state computed with the unknown wind. On the other side, the second approach solves a nonlinear minimization problem where the model used for the estimation is different from the simulation one.

Although the Nonlinear Solver approach generated promising results, its reliance on strong assumptions and susceptibility to noisy measurements, causing a fast divergence, led to its performance being considered inferior to that of the optimization approach. Indeed, the latter proved to be robust in the presence of uncertainties and flexible in the employment of constraints, derived from aerodynamic considerations.

The algorithms developed in this work will be further tested in a more complex simulation environment to test and improve their robustness, and the wind vectors estimated could be exploited to reconstruct a wind field.



Estimation results of optimization method

References:

[1] Bordignon, M.: On the estimation of the absolute wind vector in AWE systems. Master thesis, Department of Electronics, Information and Bioengineering, Politecnico di Milano, December 2023

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