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Optimal Reeling Control for Pumping Airborne Wind Energy Systems Without Wind Speed Feedback

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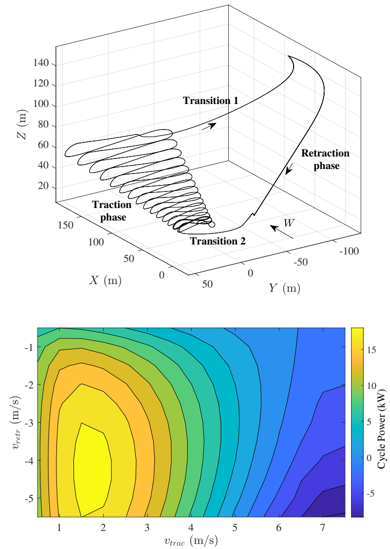
To obtain the highest conversion efficiency in pumping AWE, cycle power shall be maximized during operation (subject to constraints such as maximum tether force and tether speed limits), however this is not trivial to obtain. One reason is that the optimal reeling speed depends on the wind speed encountered by the kite, which is generally time- and space-varying and is not accurately measured. We propose a systematic approach to design feedback reeling controllers for both phases, that overcomes this problem. We employ a model of the system to estimate the response surface of power cycle as a function of reel-in and -out speeds, for different wind speed values. Then, using such a response surface we compute the manifold of optimal reeling speeds and corresponding optimal traction force values as parametrized by the wind speed. Finally, we derive a feedback law where the reference reeling speed is computed based on the measured tether force, such that these two variables converge to the found manifold. Therefore, the resulting control strategy employs tether force and speed as feedback variables, which are readily available. Simulation tests with a widely used AWE model show that the proposed approach achieves optimal performance, i.e. the same that would be obtained with an optimal reeling speed allocation assuming exact knowledge of the wind speed. After introducing the problem formulation and employed system model, the presentation will describe the various steps of the proposed approach and showcase its application in a numerical example. For more details, the interesed reader is referred to [1].



Top: example of kite path during one pumping cycle obtained with the simulation tools employed in this study. Bottom: level curves of the cycle power response surface computed with 9 m/s wind speed.

References:

[1] Andrea Berra and Lorenzo Fagiano. An optimal reeling control strategy for pumping airborne wind energy systems without wind speed feedback. In 2021 European Control Conference (ECC), pages 1199–1204, 2021.