An Efficient Optimal Control Method for AWE Systems with a Large Number of Slowly Changing Subcycles

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Motivation

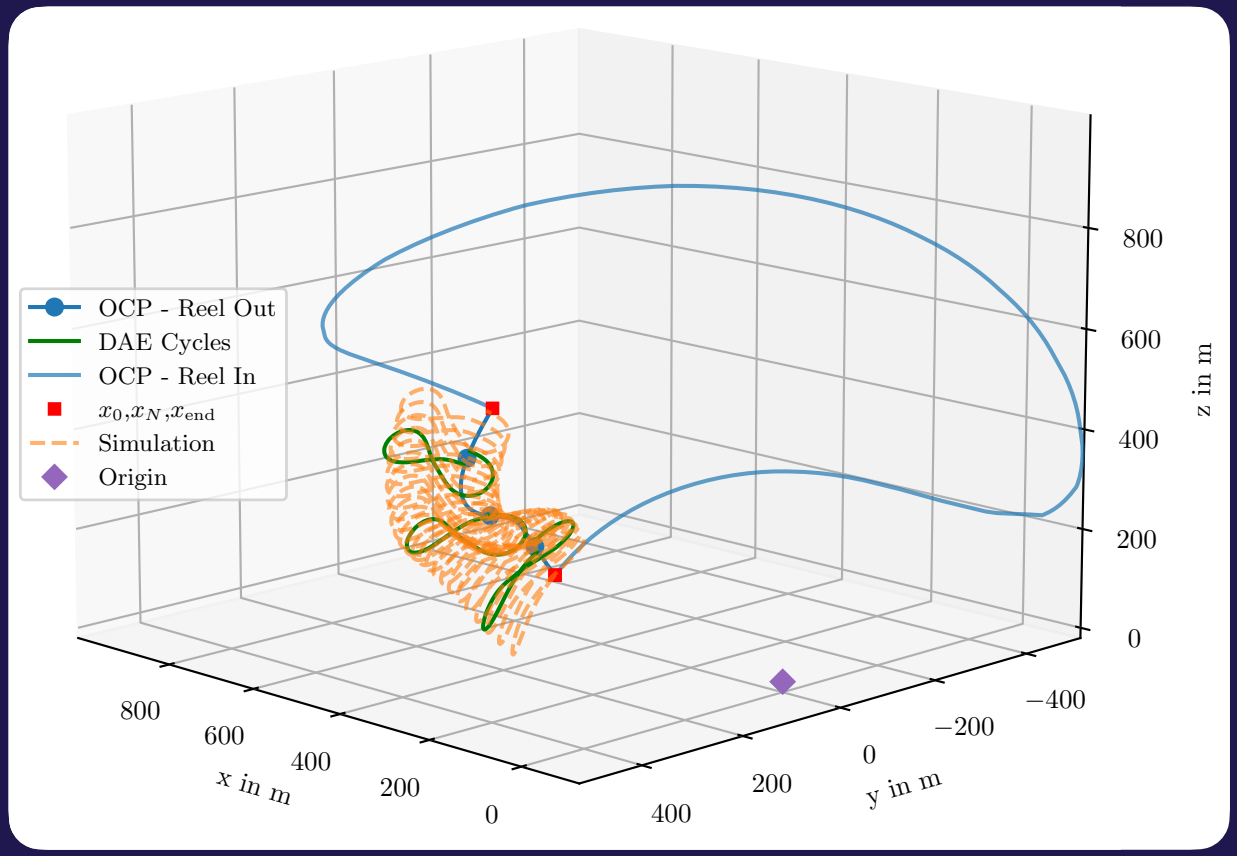
When simulating and optimizing the trajectory of a pumping AWE kite system, a large number of cycles in the reel-out phase corresponds to a large optimization problem that is numerically expensive to solve.

Methods & Results

By simulating only a subset of the larger number of the slowly changing subcylces, we can reduce the number of variables and the solution time required of the NLP.

	Full Problem	Reduced Problem
Number of Variables	30540	5397
Time per Iteration	162 ms	25 ms
Total Time	120 s	17 s
Generated Power	15.411 kW	15.651 kW

We can **efficiently optimize** the trajectory of airborne wind energy systems **over a long horizon**



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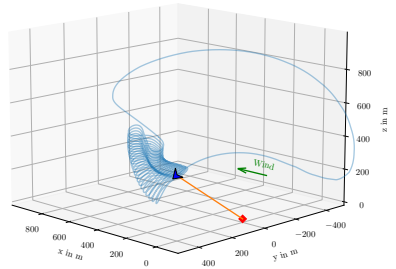
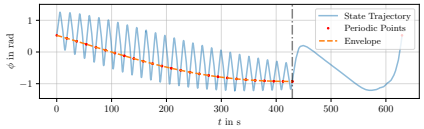
Additional Details



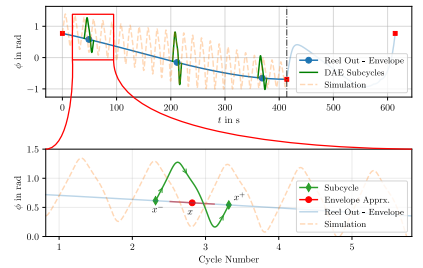
Oscillations & Envelope

In the reel-out phase, most of the states are oscillating, with a slow change over the time horizon. This slow change can be represented with an 'envelope'.



Envelope Approximation

Approximate the envelope dynamics with a DAE and only compute three subcycles when optimizing the trajectory:



References

[1] "Efficient Numerical Optimal Control for Highly Oscillatory Systems", J. Harzer, J. De Schutter, M. Diehl, *IEEE Control Systems Letters (2022)*