NCSU's marine hydrokite in the water channel (22 May 2019)

Development of Iterative Learning Strategies for Optimal Crosswind Flight of Airborne Wind Energy Systems

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As is well known, effective crosswind flight is predicated on executing efficient circular or figure-8 paths and maintaining optimal lift and drag coefficients over the duration of each cycle. The optimal parameters for both the path and the aircraft trim are known to be dependent on environmental changes and are subject to significant uncertainties, due to the nascent nature of dynamic models for AWE systems. The present work leverages the repetitive nature of crosswind flight to utilize iterative learning control (ILC) strategies in improving average power production from one lap to the next. The proposed approaches present three challenges relative to existing iterative learning control techniques, however:

1. Environmental conditions (particularly wind conditions) can change from one figure-8 cycle to the next, rendering the previous cycle's path suboptimal for the new conditions.
2. While traditional ILC approaches assume the path to be followed to be fixed and merely seek to improve performance between pre-defined waypoints along the path, the proposed techniques in this work address the more fruitful problem of iterating on the path itself.
3. While most ILC tools work in environments where there is a pause during operation, the tools developed in this work are designed for continuous operation.

This presentation will review the ILC approaches pioneered by the team at NC State, which have been validated in simulation in [1], [2], and [3] using a unique "unifoil" model that accurately captures the translational dynamics of the system but incorporates unicycle constraints on the motion of the wing to simplify the underlying path tracking problem. The presentation will review these results, which have been obtained under both constant wind and realistic variable wind scenarios, and will present an outline for future simulation and experimental validation of the proposed approaches.

References:

[1] M. Cobb, K. Barton, H. Fathy and C. Vermillion, "Iterative Learning Based Waypoint Optimization for Repetitive Path Planning, with Application to Airborne Wind Energy Systems," in IEEE Conference on Decision and Control, Melbourne, Australia, 2017.

[2] M. Cobb, K. Barton, H. Fathy and C. Vermillion, "An Iterative Learning Approach for Online Flight Path Optimization for Tethered Energy Systems Undergoing Cyclic Spooling Motion," in American Control Conference, Philadelphia, PA, 2019.

[3] M. Cobb, K. Barton, H. Fathy and C. Vermillion, "2019," Iterative Learning-Based Path Optimization for Repetitive Path Planning, with Application to 3D Crosswind Flight of Airborne Wind Energy Systems (accepted), 2019.