Kite Path–following with L0 and L1 Controllers Tested on a Small–scale Prototype

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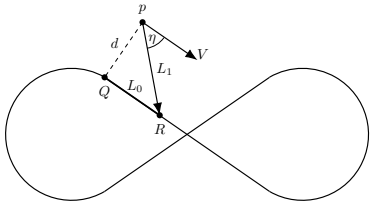
We address the problem of controlling an aircraft of an airborne wind energy system (AWES) to follow a prescribed geometric path. We consider two path-following guidance methods, the L1 and the L0 controllers, adapt them to AWES, implement them in *Ardupilot*, analyse their behaviour, and compare their performance.

The L1 controller is based on an well–known guidance logic reported in [1], while the L0 controller is a modification of the previous controller, described in [2,3], which removes the need to switch control laws when operating far from the reference path. The L1 controller considers the current kite position p and a predetermined design parameter L_1, representing the distance from the kite to a reference target point R in the desired path. This defines the location of R as well as the heading of the vector L_1, thereby defining its angle η with the kite velocity vector V. The lateral acceleration a_s needed for the kite to join the path at R can be computed by $a_s = 2\frac{V^2}{L_1} sin(\eta)$.



Path to be followed and signals involved.

In the L0 controller, the design parameter is now L_0, representing the distance from the closest point Q in the path to the reference target point R. These variables also determine the location of the point R, as well as the quantities L_1 and η, allowing a_s to be computed using the same formula as before.

We have implemented the techniques in *Ardupilot* and carried out software-in-the-loop simulations with the help of JSBsim. The simulations allowed the performance comparison of both controllers under fast changing wind conditions, such as wind gusts. The L0 controller exhibited a better performance when measured in terms of the average cross–track error [3]. The L_0, L_1 parameters can be adjusted accordingly to the flight characteristics of the aircraft to achieve the desired behavior converging to the path.

Field tests were carried out on a small-scale aircraft prototype to extract real flight data. The data confirms the conclusions obtained in the simulations regarding the ability to follow closely the reference path.

References:

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[3] Fernandes, M.C.R.M.; Vinha, S.; Paiva, L.T.; Fontes, F.A.C.C.: L0 and L1 Guidance and Path-Following Control for Airborne Wind Energy Systems. Energies 2022, 15, 1390. doi: 10.3390/en15041390.