



Manuel C.R.M. Fernandes

PhD Candidate

Universidade do Porto

Faculty of Engineering

Dept. of Electrical & Computer Engineering
SYSTEC-ISR, UPWIND Project

Rua Dr. Roberto Frias, s/n
4200-465 Porto
Portugal

mcrmf@fe.up.pt
www.upwind.pt



Model Predictive Path-Following Control of Airborne Wind Energy Systems with Guaranteed Stability

Manuel C.R.M. Fernandes , Sérgio Vinha , Luís Tiago Paiva , Fernando A.C.C. Fontes
Universidade do Porto

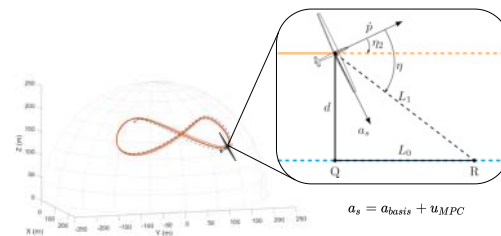
In AWES concepts in which the power generation is done with a kite flying crosswind, a pre-specified, optimized, cyclic path should be followed closely. Here we address the problem of devising a controller for a kite to follow the pre-specified path.

We propose a Model Predictive Control (MPC) scheme that is added to an existing basis path-following controller. The MPC scheme aims to improve the performance of the original controller, while maintaining its stabilizing properties. We start with a basis path-following guidance law, named L0 guidance logic, that was demonstrated to have a large domain of attraction and global asymptotic stability [1], and add a MPC control law on top of it. The usage of this combined controller has been shown to offer several benefits:

1. the stability of the resulting system is guaranteed by means of an adequate selection of the MPC design parameters [2];
2. the combined controller can only improve the performance of the basis controller;
3. the MPC numerical optimization can be efficiently solved, since the basis controller offers an already feasible initial solution to start with;
4. the method is robust to an optimization failure, since the initial solution is already an adequate one.

We present simulation results gathered using Matlab in order to evaluate the MPC Path-Following controller ap-

plied to a crosswind flying kite. The simulation results confirm the expected performance increase of the combined controller.



MPC Path-Following Controller descriptive image.

References:

- [1] Silva, G.B., Paiva, L.T., Fontes, F.A.C.C.: A Path-following Guidance Method for Airborne Wind Energy Systems with Large Domain of Attraction. *IFAC Proceedings of 2019 American Control Conference*, pp. 2771-2776, Philadelphia, USA, July (2019). <https://doi.org/10.23919/ACC.2019.8815322>
- [2] Fontes, F.A.C.C.: A General Framework to Design Stabilizing Nonlinear Model Predictive Controllers. *Systems & Control Letters*. **42**(2), pp. 127-143, February (2001). [https://doi.org/10.1016/S0167-6911\(00\)00084-0](https://doi.org/10.1016/S0167-6911(00)00084-0)
- [3] Fernandes, M.C.R.M., Paiva, L.T., Fontes, F.A.C.C.: A Model Predictive Control Scheme to Improve Performance of a Path-following Controller for Airborne Wind Energy. *Technical Program of the 21st IFAC World Congress (Paper VI163-15.3)*, Berlin, July (2020).