Trajectory Optimisation for Fixed Wing UAVs

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Aims

- To treat the circuit of the IMechE UAS Challenge as an optimal control problem and solve it using MATLAB and ICLOCS2 [1].
- Compare the minimum time and minimum energy simulations to the actual flight path from this year's competition [3].
- Develop software that can later be repurposed for use by future teams for mission planning.

Method

- Used empirical log data and a simple XFLR/flow5 model to estimate aerodynamic coefficients.
- Used a simplified point mass model for the flight dynamics [2].
- Reworked a pre-existing set of MATLAB scripts to match the dimensions of the drone and to incorporate the dynamics of the battery.
- Ran various test cases constraining height and speed and changing various parameters to evaluate sensitivity in solution and objective value.

Figure 1: *Team photo with our drone, "SHARD".*

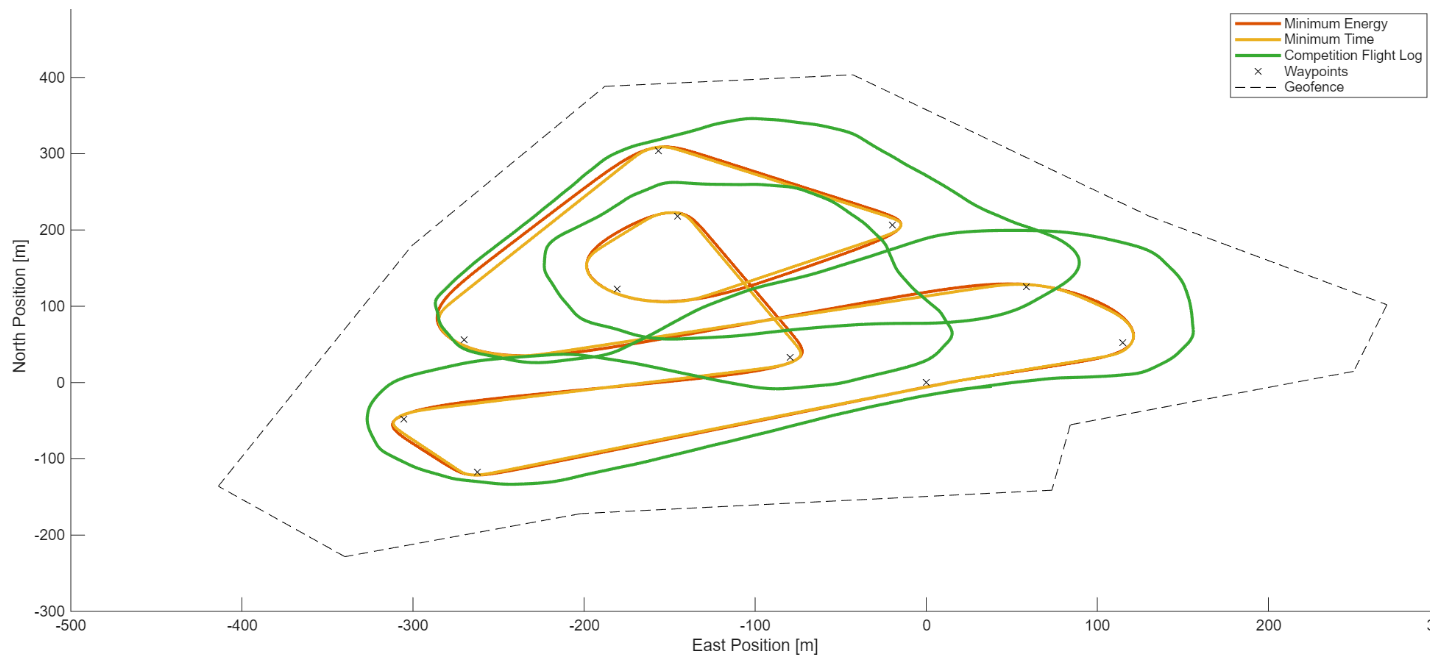

Figure 2: *Bird's eye view of competition cruise loop, comparing both real life and simulated optimal trajectories.*

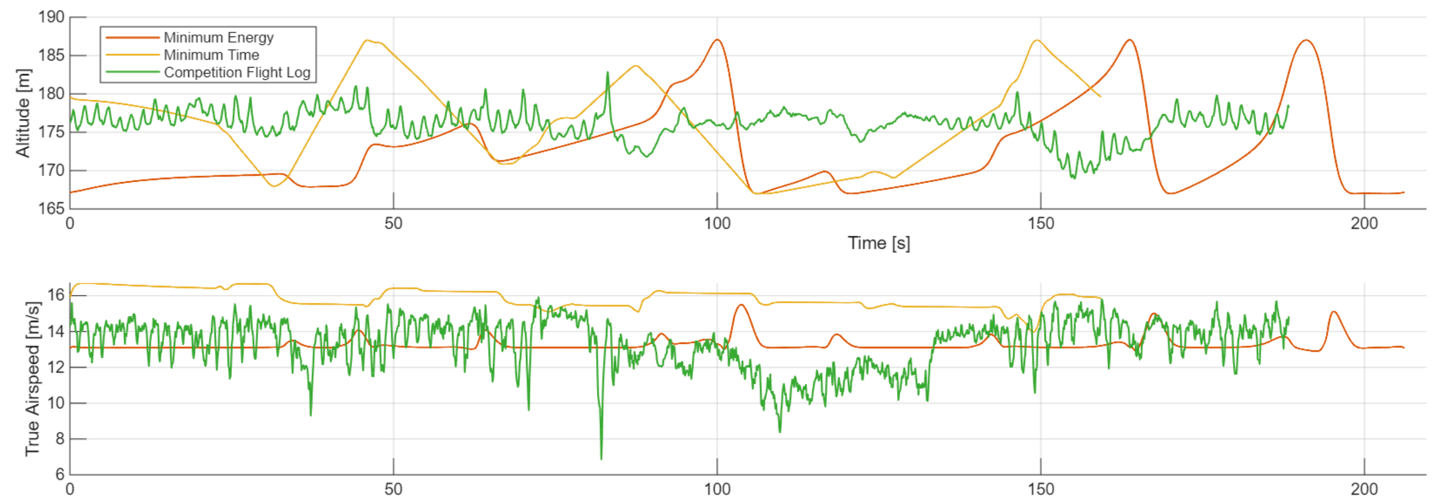

Figure 3: *True Airspeed and Altitude over time*

Results

- Optimal solutions for time and energy favoured much tighter turns than our manually planned real life route
- Height strategy was found to be sensitive to drag coefficients, however constraining height had negligible effects on lap time and energy consumption.
- North-East trajectory changes with drag coefficients but only by a small amount.
- This means that solution will be close to optimal in spite of uncertainties in drag coefficients.

Limitations/Further Research

- Empirical testing could be done to verify feasibility of generated solutions
- More advanced dynamics model including moment effect of tilt rotors and aircraft response to control surface deflection
- Inclusion of take-off/landing phases to guarantee full mission optimality
- Development of plug and play application for future teams

References

[1] "ICLOCS2: A MATLAB Toolbox for Optimization Based Control," ic.ac.uk, 2018. http://www.ee.ic.ac.uk/ICLOCS/default.htm
[2] Y. Nie and E. C. Kerrigan, "External constraint handling for solving optimal control problems with simultaneous approaches and interior point methods," IEEE Control Systems Letters, vol. 4, no. 1, pp. 7–12, 2020.
[3] N. E. Courtier, R. Drummond, P. Ascencio, L. D. Couto, and D. A. Howey, "Discretisation-free battery fast-charging optimisation using the measure-moment approach," IEEE Xplore, Jul. 01, 2022. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9838296 (accessed Jul. 25, 2025).

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