



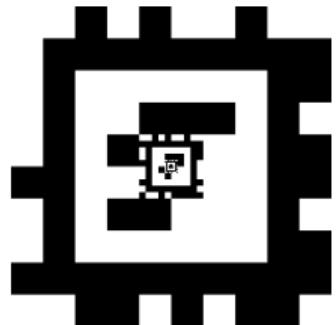
Autonomous Drone Landing with Fiducial Markers and a Gimbal-Mounted Camera for Active Tracking

Joshua Springer, Marcel Kyas

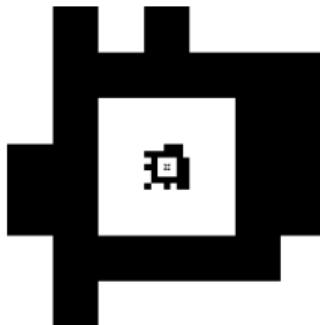
7 December 2022

Reykjavik University
Department of Computer Science

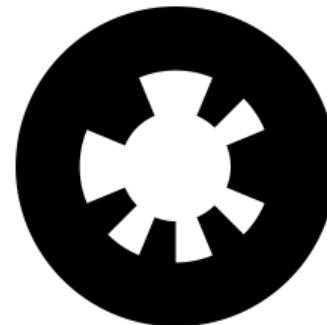
Fiducial Markers



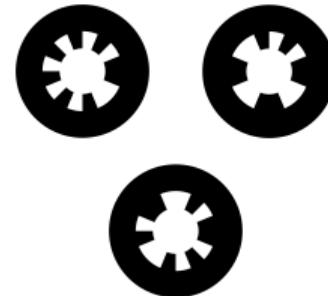
April Tag 48h12¹



April Tag 24h10



WhyCode² (Orig)



WhyCode Multi

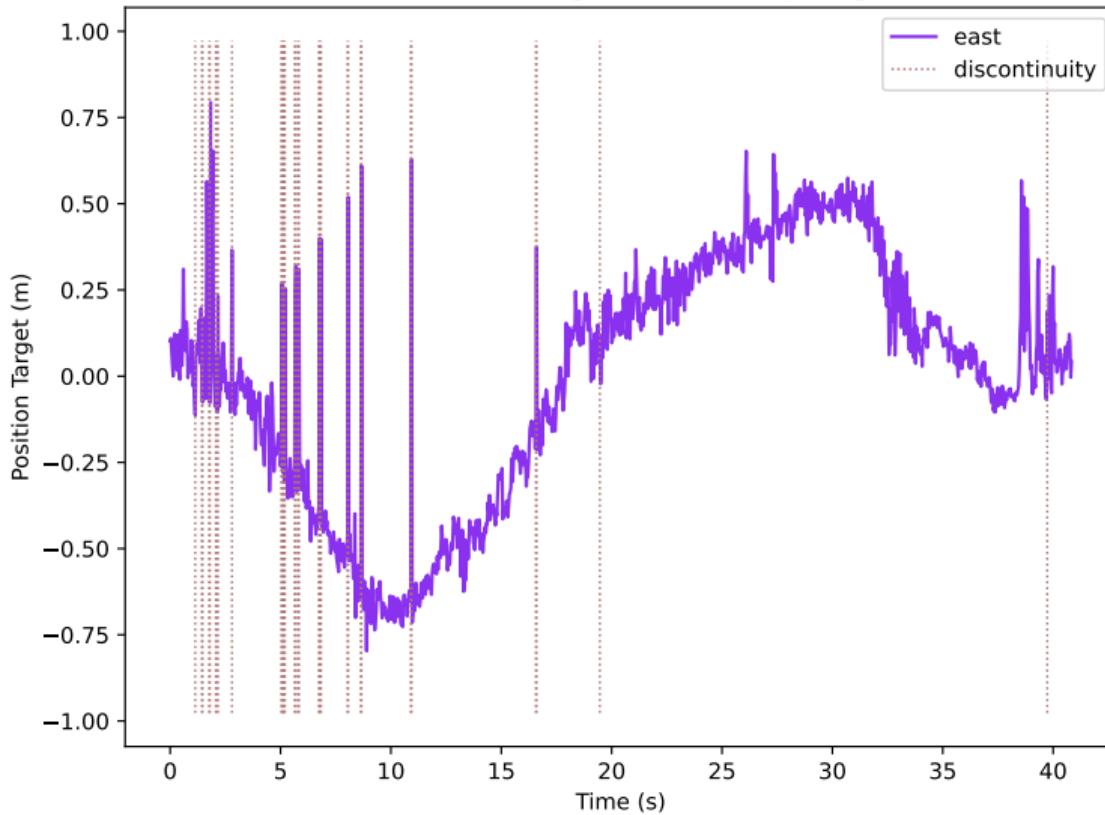
- ▶ Marker *position* → accurate
- ▶ Marker *orientation* → ambiguous

¹Krogius, Haggenmiller, and Olson 2019.

²Lightbody, Krajiník, and Hanheide 2017.

Orientation Ambiguity

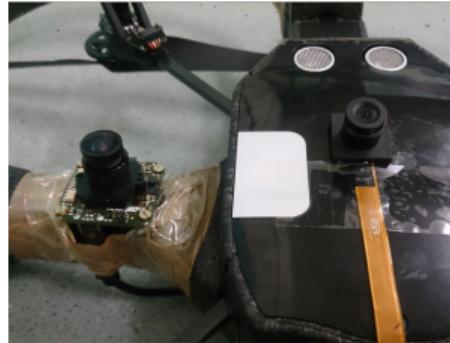
Test case: orbit-left-right-4, Marker: apriltag48h12



The Downward-facing Camera Paradigm



Single fixed camera.³



Dual fixed cameras.⁴



Gimbal/fixed cameras.⁵

- We want to leverage the standard monocular, gimbal-mounted camera.

³Wubben et al. 2019.

⁴Araar, Oualid and Aouf, Nabil and Vitanov, Ivan 2017.

⁵Borowczyk et al. 2017.

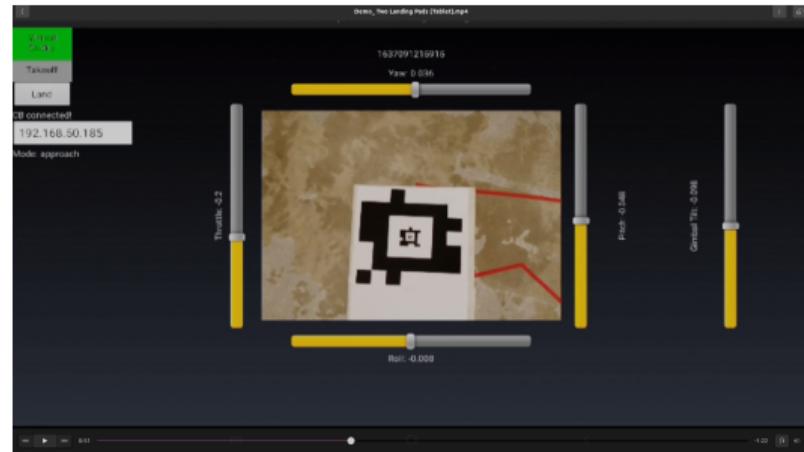
Testing Platform: DJI Spark

- ▶ Small quadcopter
- ▶ Gimbal-mounted camera
- ▶ DJI Mobile SDK

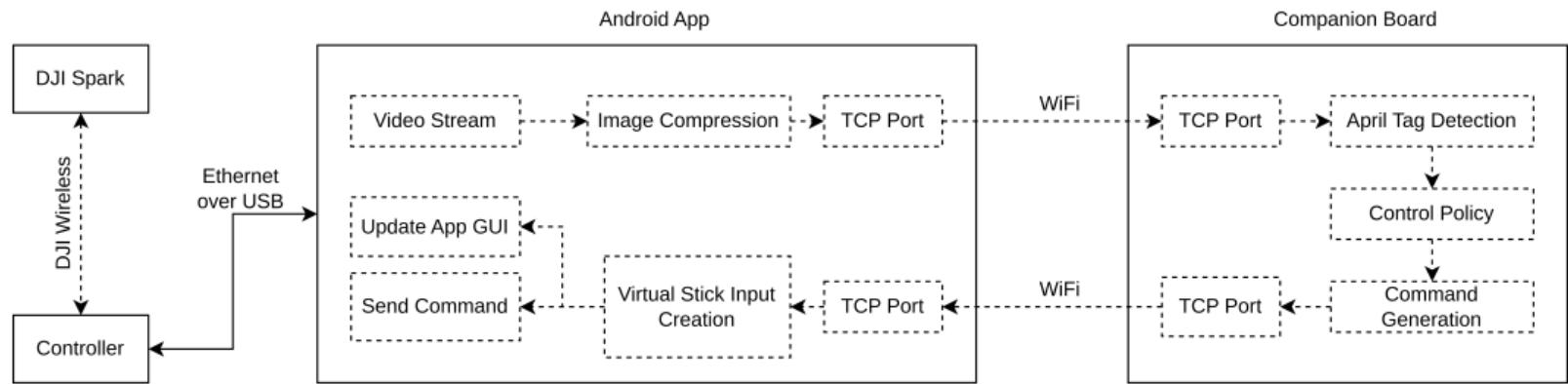


Testing Platform: Software Side

- ▶ DJI Mobile SDK: App-style architecture
- ▶ Export video to Raspberry Pi 4 companion board
- ▶ Return control signals

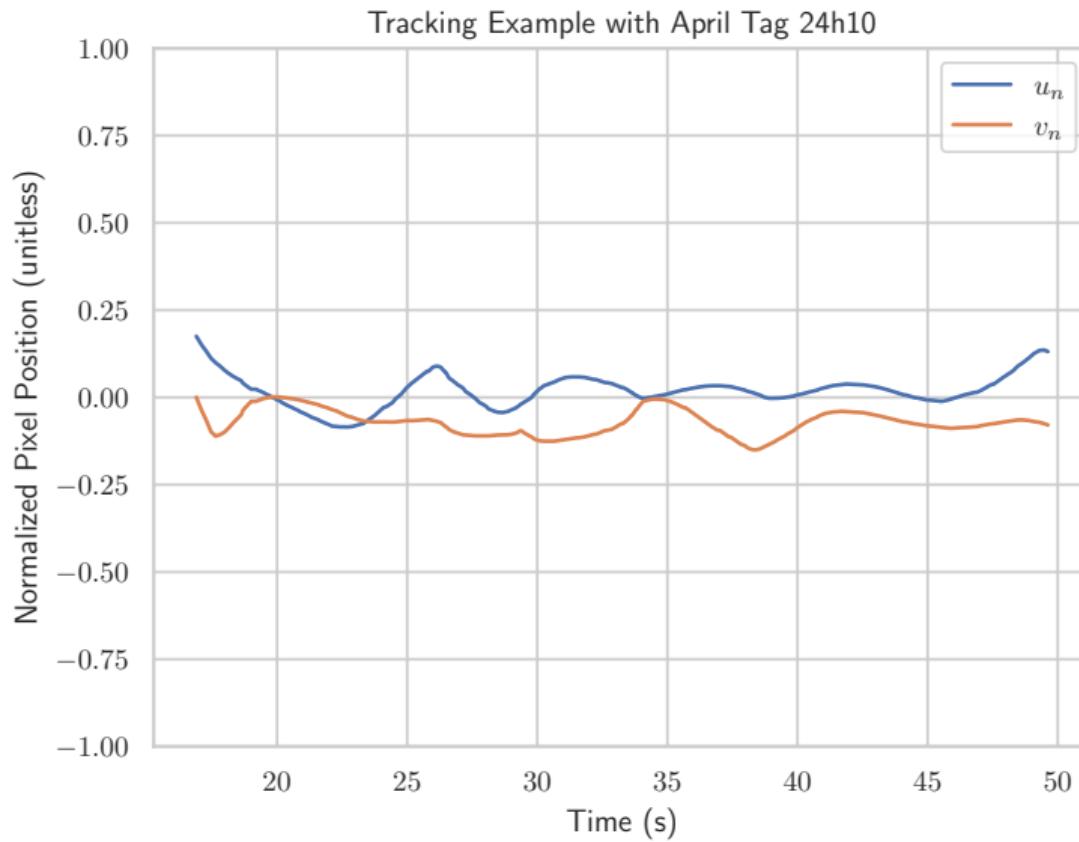


Data Flow



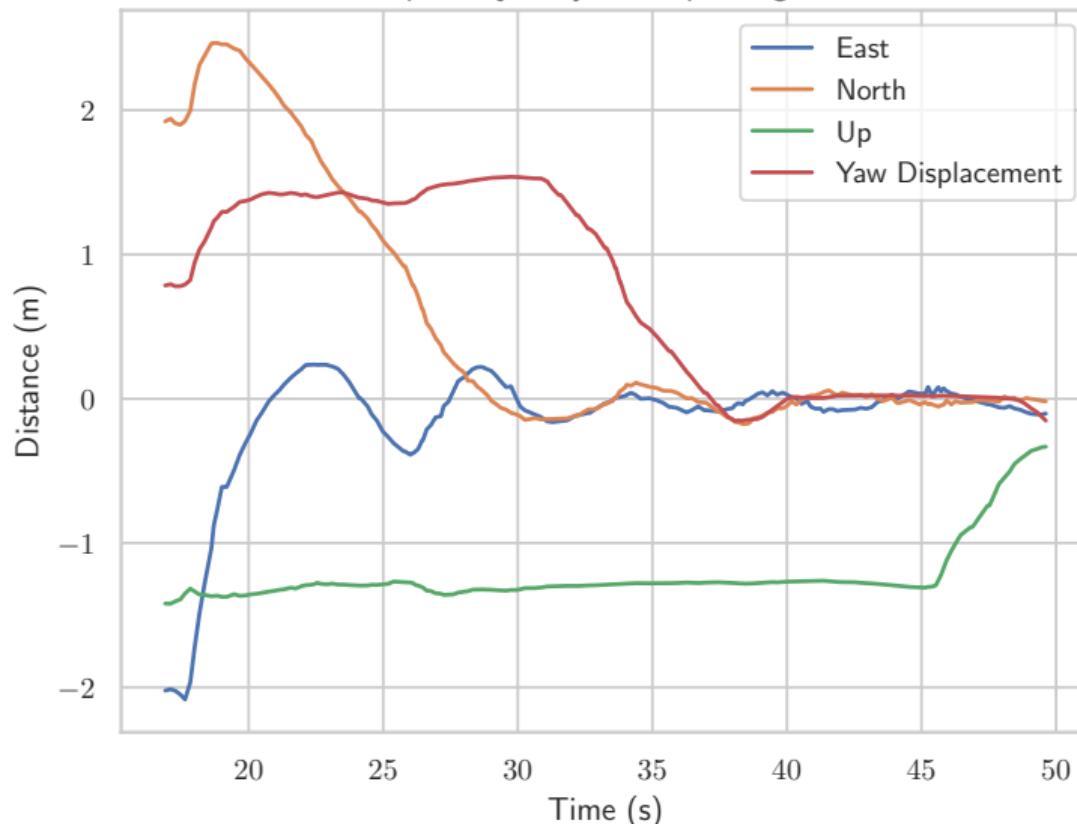
Demonstration Video

Example Tracking Performance

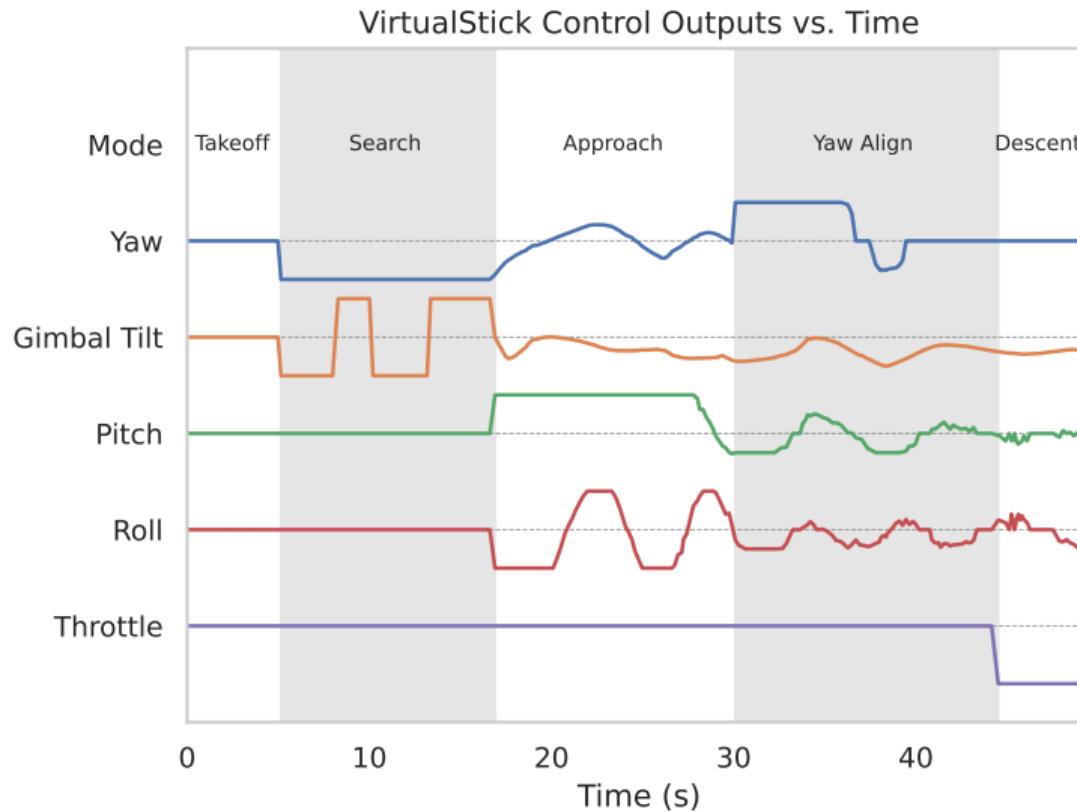


Example Landing Trajectory

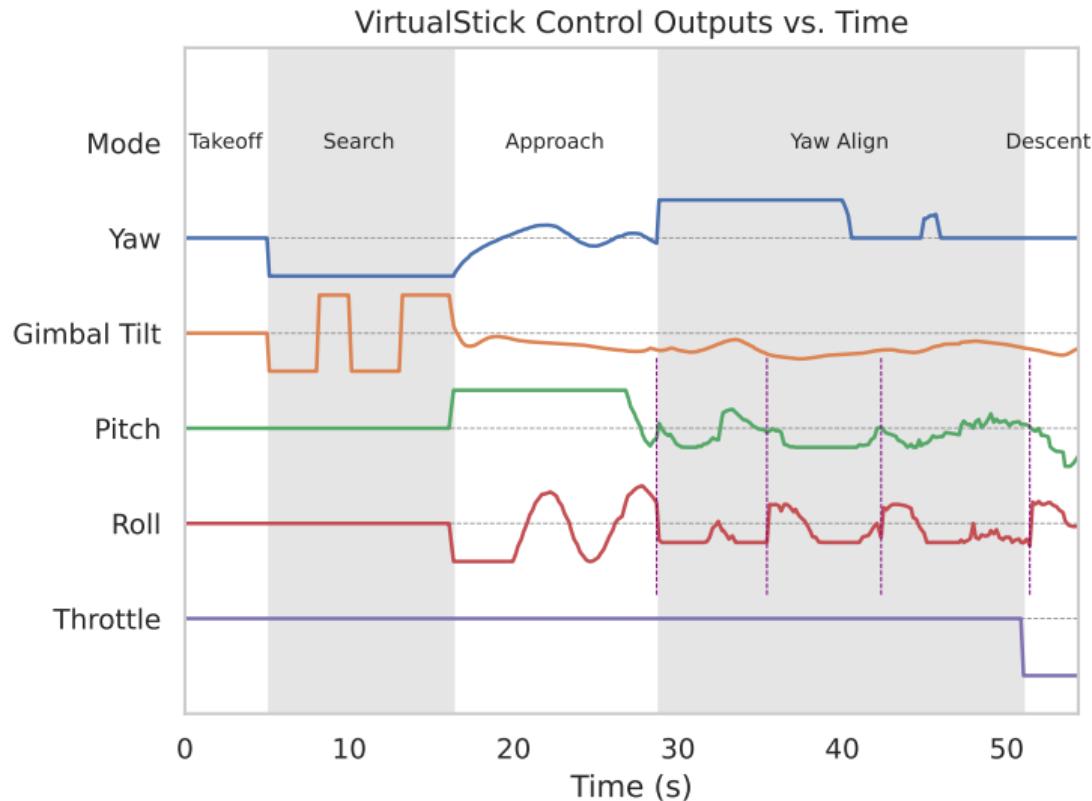
Example Trajectory with April Tag 24h10



Example Control Outputs

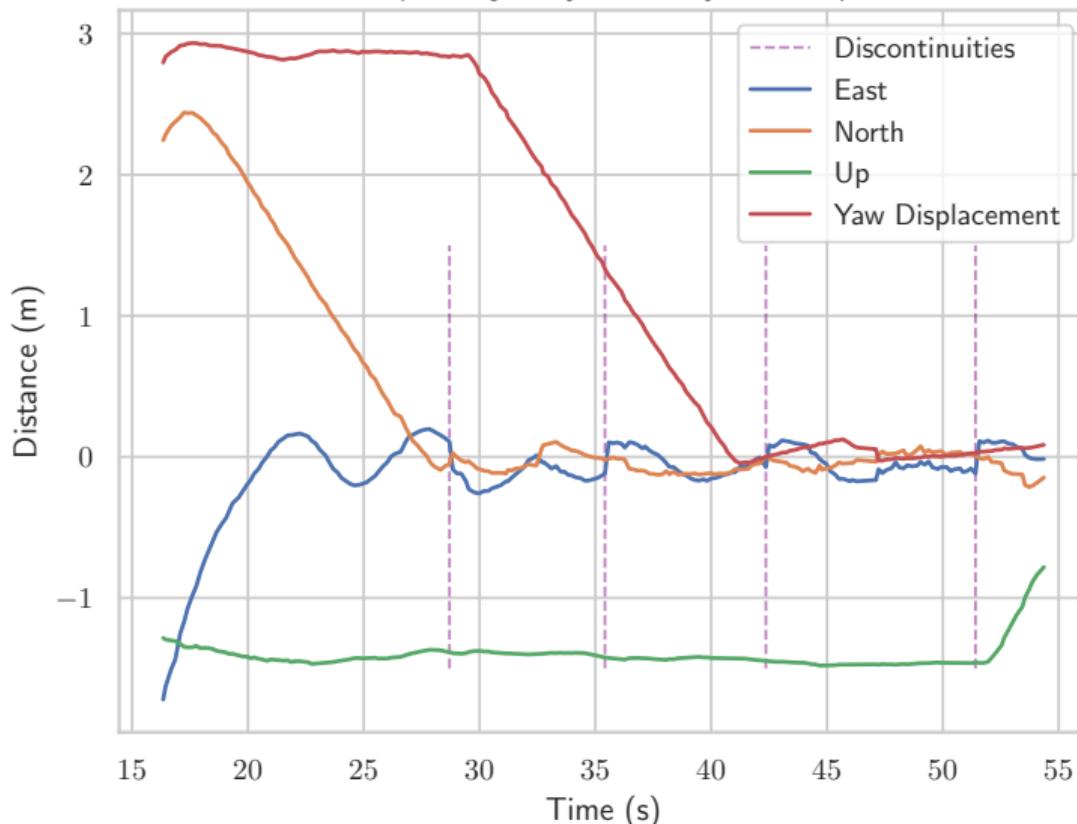


Control Outputs With Discontinuities



Landing Trajectory with Discontinuities

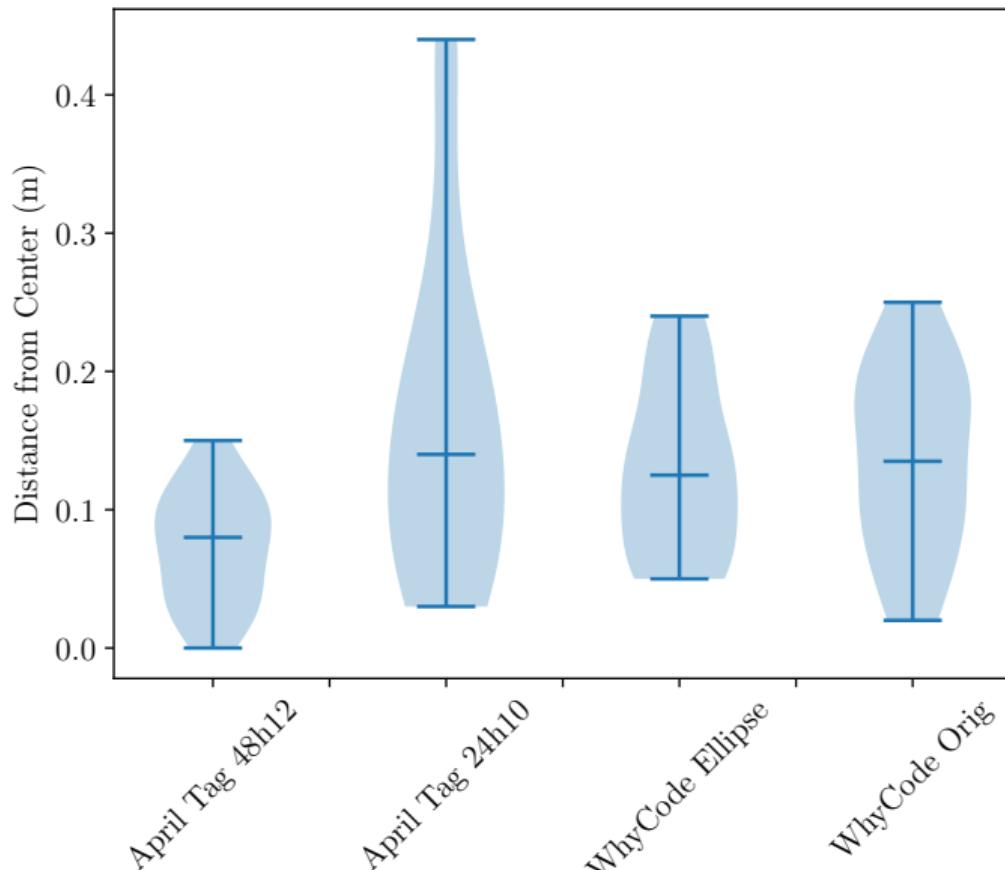
Example Trajectory with WhyCode Ellipse



Landing Error (Lower is better!)

Factors:

- ▶ Orientation ambiguity
- ▶ Landing commit height



Future Work

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 - ▶ Marker *position* and gimbal *orientation* for pose transforms

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- ▶ *Actuated, gimbal-mounted camera* → easier to search for the landing pad.

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- ▶ Orientation ambiguity, discontinuities → pose estimation is harder.
- ▶ Autonomous precision landing still possible but can be improved.