



Autonomous Multirotor Landing on Landing Pads and Lava Flows

Joshua Springer

7 December 2022

Reykjavik University

Department of Computer Science

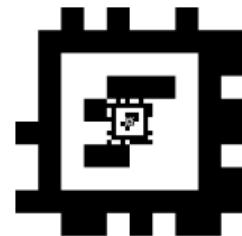
Supervisor: Marcel Kyas

Topic Overview

- ▶ Autonomous drone landing: hard, needs to be precise
- ▶ Often depends on GPS, blind to obstacles
- ▶ Often needs to be more precise than GPS (or GPS-denied)
- ▶ Landing pads: fiducial markers
- ▶ Terrain analysis
- ▶ Aesthetics:
 - ▶ GPS-independent
 - ▶ Embedded processing only → efficient, quick, dedicated hardware
 - ▶ No active ground infrastructure (e.g. ground stations with telemetry, computing hardware)
 - ▶ Prefer passive sensors (e.g. RGBD cameras instead of LIDAR/RADAR)

Structured Case: Landing Pads

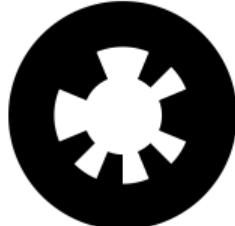
Fiducial Markers



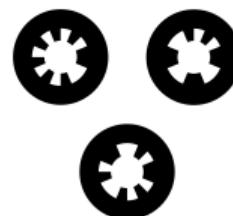
April Tag 48h12¹



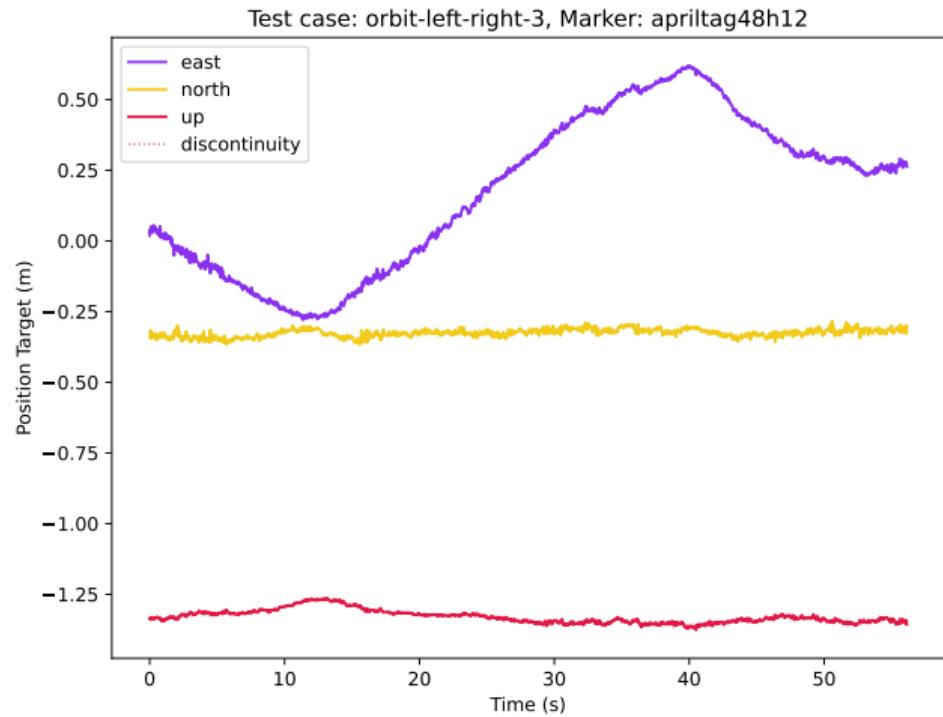
April Tag 24h10



WhyCode (Orig)²



WhyCode Multi

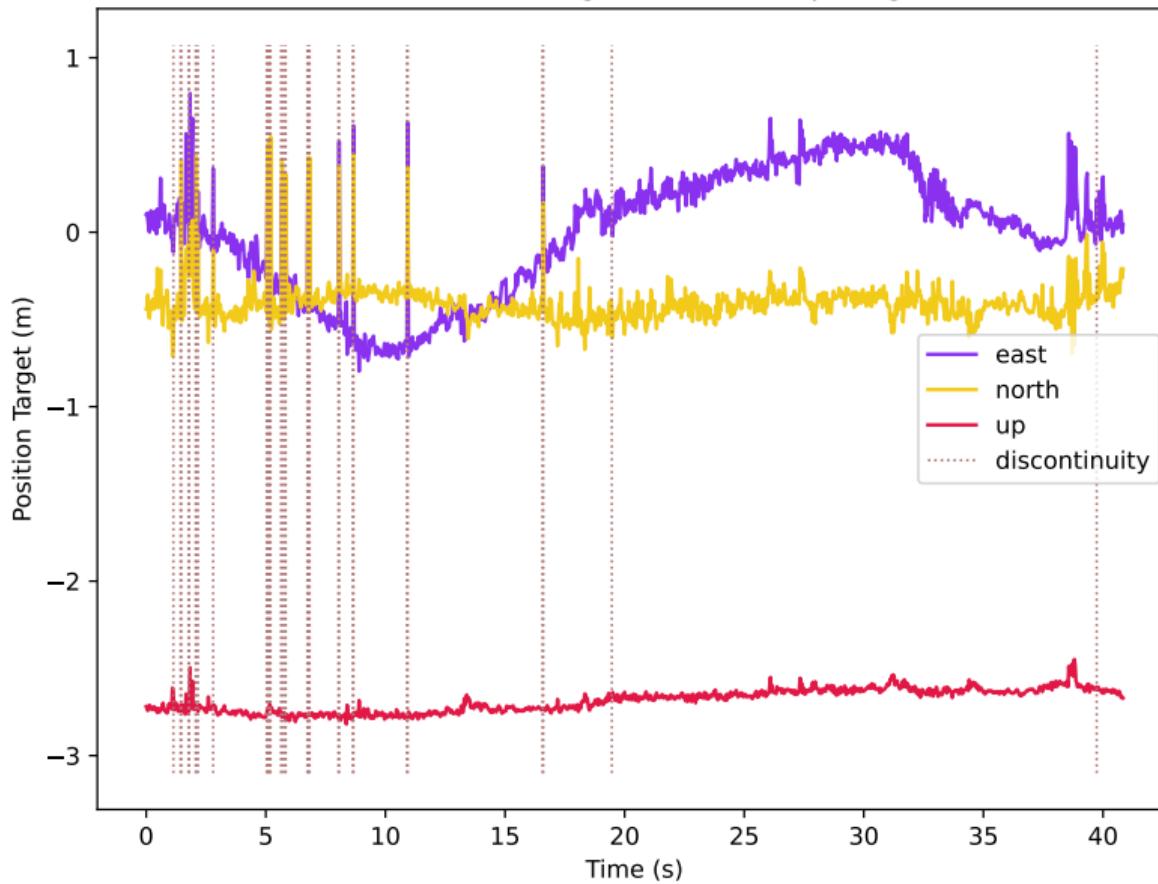


¹Krogius, Haggenmiller, and Olson 2019

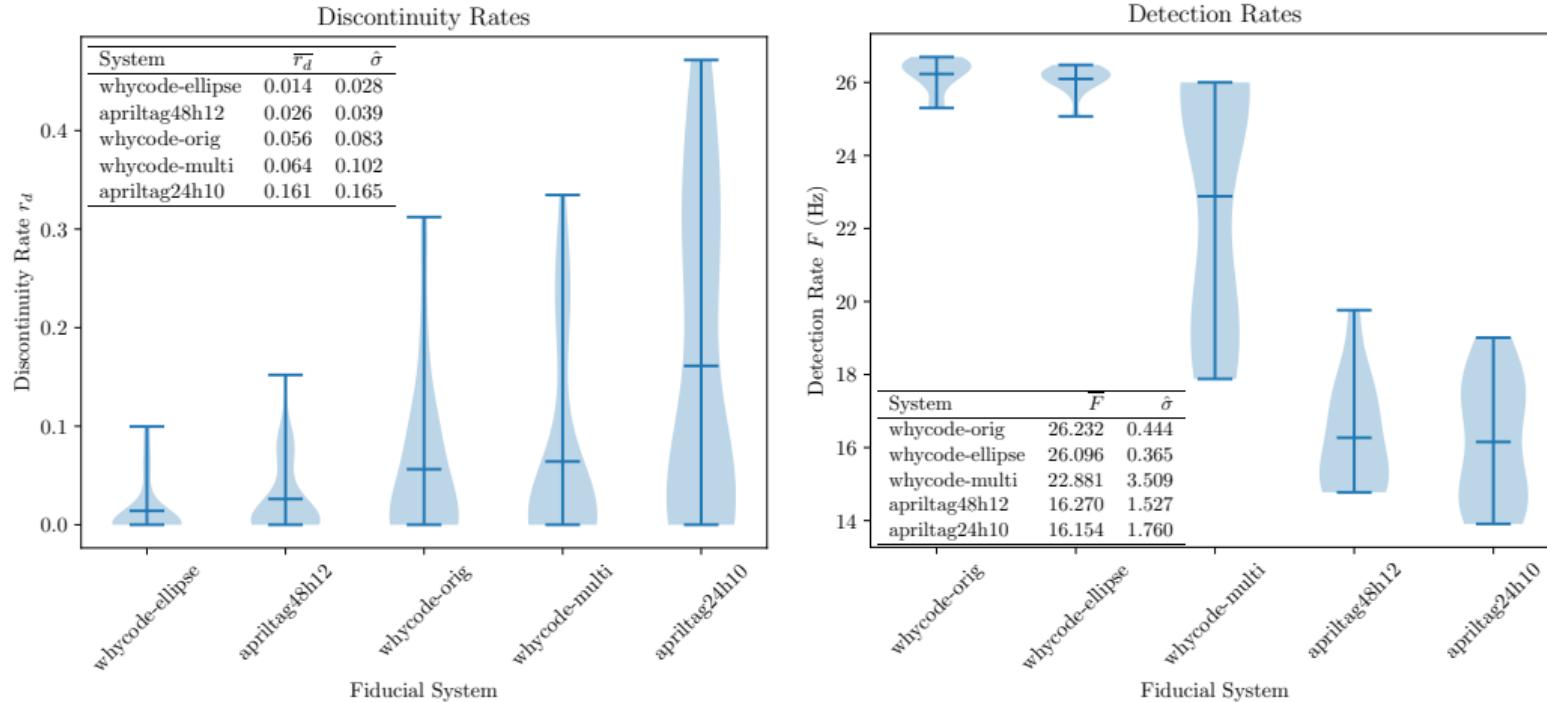
²Lightbody, Krajiník, and Hanheide 2017

Discontinuities

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



Evaluation Results



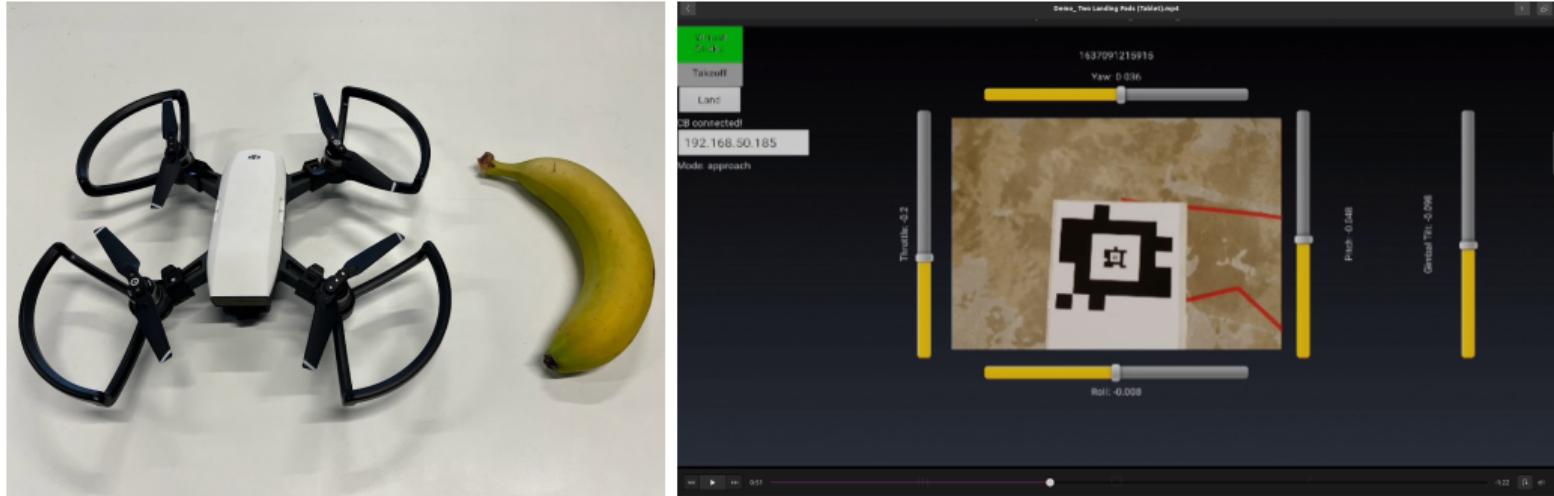
Landing Pads with Fiducial Markers



Figure 1: Classic, downward-facing, fixed camera. Wubben et al. 2019

- ▶ Fixed, downward-facing camera paradigm
- ▶ Loses sight of the landing pad in adverse conditions (e.g. wind)

Proof of Concept Landing with Actuated Camera



Demonstration Video

Future Work: Fiducial Tests

- ▶ Re-conduct fiducial landing tests with actuated camera
- ▶ Raw pose data (same as before)
- ▶ Filtered pose data (KF, etc)
- ▶ Hybrid data
 - ▶ Position from marker
 - ▶ Orientation from camera gimbal



Unstructured Case: Lava Flows

RAVEN, Mars Analog Missions in Iceland



Jonathan Bapst et al. "Mars Science Helicopter: Compelling Science Enabled by an Aerial Platform". In: *Bulletin of the AAS* 53.4 (Mar. 2021). URL:

<https://baas.aas.org/pub/2021n4i361>

RAVEN, Mars Analog Missions in Iceland



Lava Flow Landings



Manual Lava Landing Video

Reykjavík University = No-Fly Zone



Lava Flow Landing Data Collection Area: Stóra-Bolluhraun



Data Collection Video

Moving Forward

- ▶ Transform depth image using IMU
- ▶ Conventional signal processing techniques
- ▶ Possible: Deep learning (embedded TPU/GPU)
- ▶ Synthetic data generation using LIDAR point clouds: AirSim
- ▶ Analog² Missions
- ▶ New lava flows + ground penetrating RADAR
- ▶ Combine fiducial and lava flow methods into a single platform

Main Messages



- ▶ Topic: autonomous drone control – landing
- ▶ Methods:
 - ▶ Fiducial markers with camera actuation
 - ▶ Lava flow landings: terrain analysis with RGBD camera + IMU
 - ▶ Embedded processing only, no active ground infrastructure
- ▶ Are there any questions?