Autonomous Multirotor Landing on Landing Pads and Lava Flows

Joshua Springer

7 December 2022

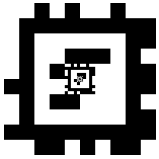
Reykjavik University
Department of Computer Science
Supervisor: Marcel Kyas

Topic Overview

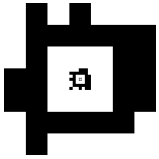
- Autonomous drone landing: hard, needs to be precise
- Often depends on GPS, blind to obstacles
- Often needs to be more precise than GPS (or GPS-denied)
- Landing pads: fiducial markers
- Terrain analysis
- Aesthetics:
  - GPS-independent
  - Embedded processing only $\rightarrow$ efficient, quick, 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

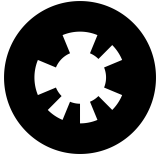
Fiducial Markers



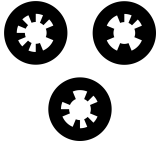
April Tag 48h12



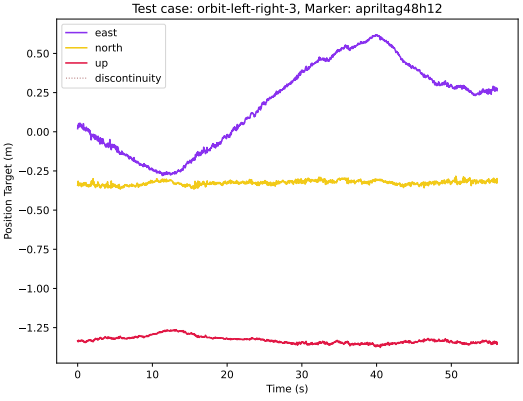
April Tag 24h10



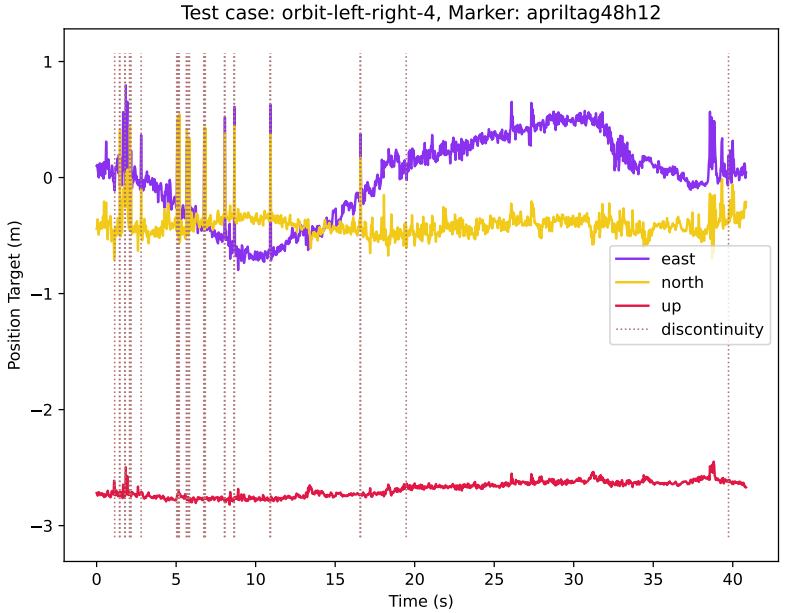
WhyCode (Orig)



WhyCode Multi



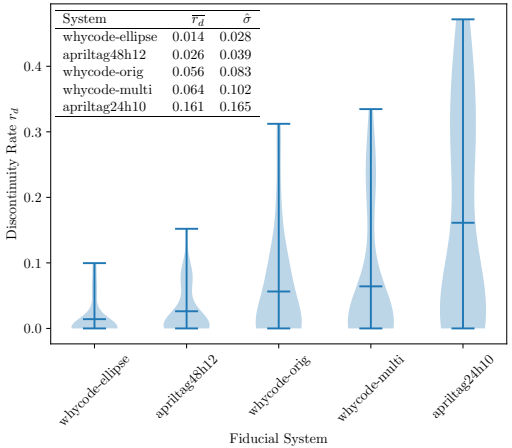
Discontinuities



Evaluation Results

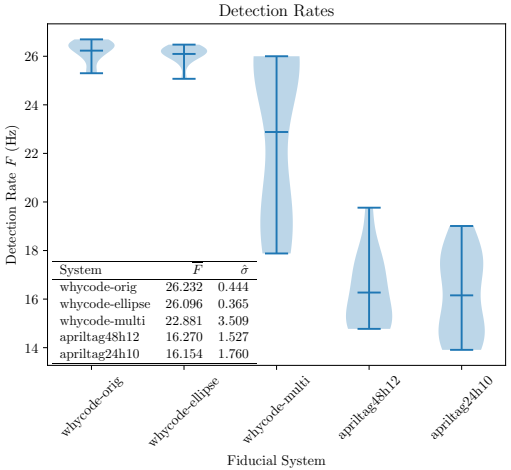
Discontinuity Rates

System	$\overline{r_d}$	$\tilde{\sigma}$
whycode-ellipse	0.014	0.028
apriltag48h12	0.026	0.039
whycode-orig	0.056	0.083
whycode-multi	0.064	0.102
apriltag24h10	0.161	0.165



Detection Rates

System	$\overline{F}$	$\tilde{\sigma}$
whycode-orig	26.232	0.444
whycode-ellipse	26.096	0.365
whycode-multi	22.881	3.509
apriltag48h12	16.270	1.527
apriltag24h10	16.154	1.760



Landing Pads with Fiducial Markers

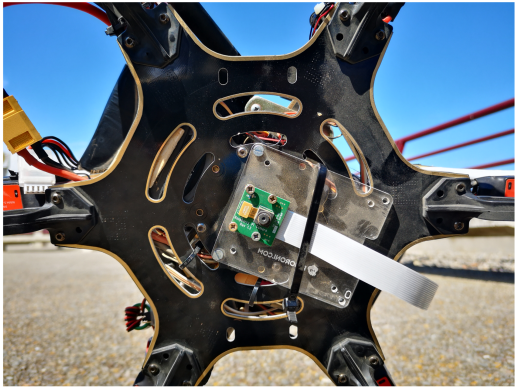
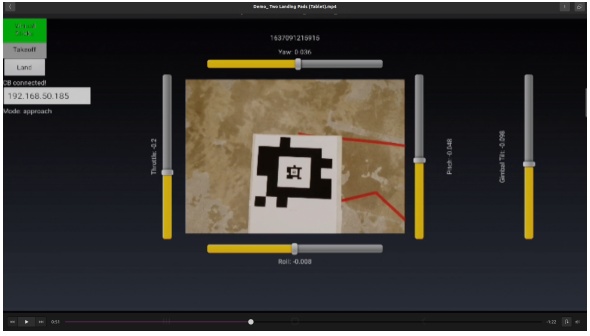


Figure 1: Classic, downward-facing, fixed camera. Wubben et al. 2019

- 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

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

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
- Analog^2 Missions
- New lava flows + ground penetrating RADAR

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
- Combine fiducial and lava flow methods into a single platform
- Are there any questions?