Real Time, Onboard-only Landing Site Evaluation for Autonomous Drones

PhD Thesis Proposal

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Presentation Structure

(1) Introduction
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Introduction

Problem Description and Motivation

- Most of drone flight has been **automated**.
  - Takeoff
  - Waypoint-to-waypoint-flight
  - Miscellaneous tasks: track/orbit an object, take a picture, etc.
- Landing is still done **manually**.

“Human-assisted landing”

State of the Art

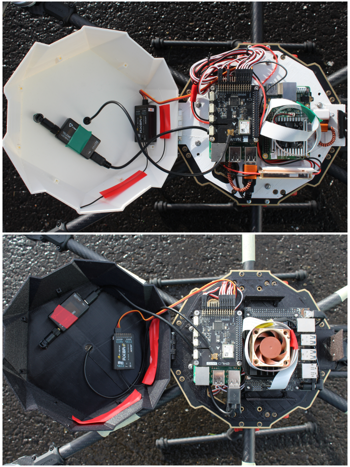
Current Progress

Test Hexacopters

- Two Tarot 680 hexacopters
- For real-world proof of concept of master thesis simulations.

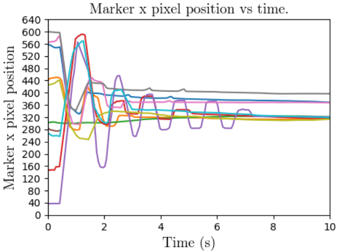
Test Hexacopters' Components

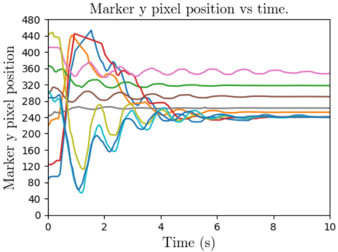
- Navio2 + RPi 3 autopilot combo
- Companion boards:
  - Google Coral (embedded TPU)
  - Jetson Nano (embedded GPU)
- Gimbaled camera modules
- 433 MHz telemetry
- 2.4 GHz R/C control



Test Hexacopters' Performance

- Stable flight performance
- > 20 min flying time
- Successful marker tracking
- Errors during approach
  - Monocular pose estimation ambiguity
  - GPS inaccuracy
- No successful autonomous landing (but almost)





Fiducial System Modifications

Necessary properties:

- Overcome orientation ambiguity
- Maintain visibility of the marker at both long- and short- distances
- Be adequately computationally efficient to run on embedded hardware.

Fiducial System Modifications: WhyCode

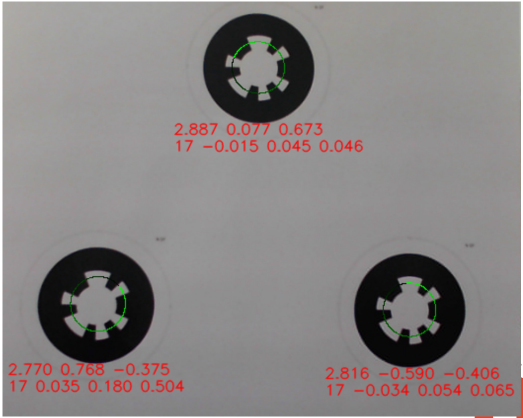
Approach 1: Extra tooth sampling

- Original: elliptical sampling through the teeth
- Added: radial sampling at tooth edges
- Takes better advantage of camera distortion

Fiducial System Modifications: WhyCode

Approach 2: Planar regression from 3+ coplanar markers

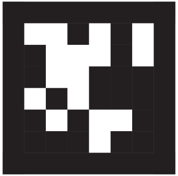
- Calculate normal vector to the plane connecting the markers.
- Deduce pitch and roll from the normal vector.
- Extract yaw from the markers.
- Takes advantage of WhyCode's efficiency.



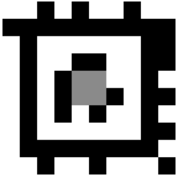
Fiducial System Modifications: April Tag

April Tag: less orientation ambiguity, but less computationally efficient.

Tag 36h11: original, most common. Eclipses camera's field of view when viewed from too close.



Tag custom48h12: more sophisticated, "recursive."



Fiducial System Modifications: Performance Analysis

Heavy Lift IR Drone

- Project with Christopher Hamilton (geologist, University of Arizona)
- 1.3 m span, 25 kg lift
- FLIR camera
- Surveyed lava field at Fagradalsfjall
- Featured on BBC Click

Autonomous Landing Proof of Concept **(FINALLY!)**

Research Plan

Data Set Generation

Terrain Classifier Creation

Testing in Simulation

Testing in the Real World

Drone Upgrades

Risk Analysis

References