

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

## PhD Thesis Proposal

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# Presentation Structure

## (1) Introduction

- Problem Description
- Motivation
- State of the Art

## (2) Current Progress

- Completed/ongoing projects
- Challenges

## (3) Research Plan

- Methods
- Risk Analysis



# 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



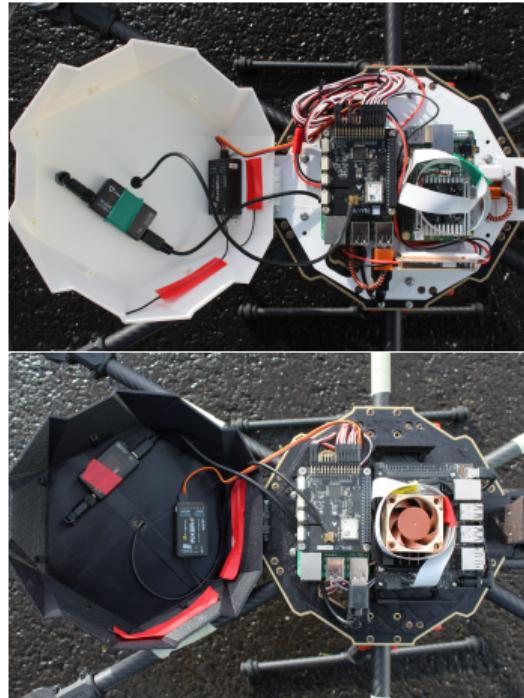
# Test Hexacopters

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



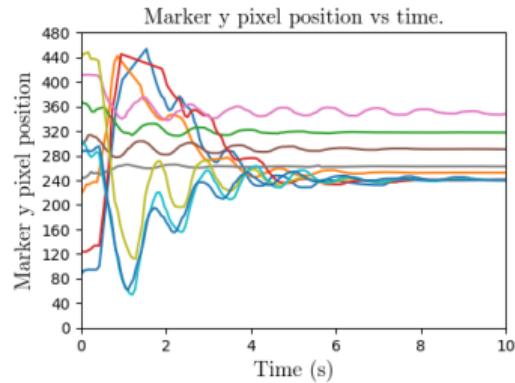
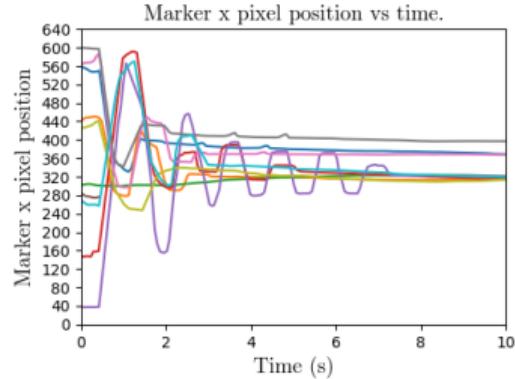
# Test Hexacopters' Components

- 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:

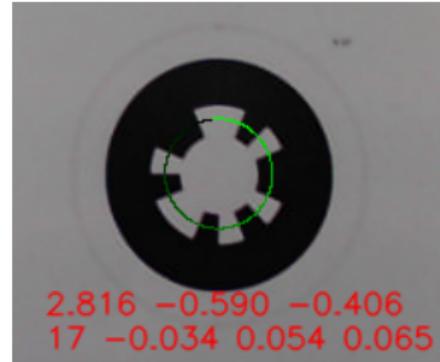
- Overcome orientation ambiguity
- Maintain visibility of the marker at both long- and short- distances
- Be adequately computationally efficient to run on embedded hardware.



# Fiducial System Modifications: WhyCode

## Approach 1: Extra tooth sampling

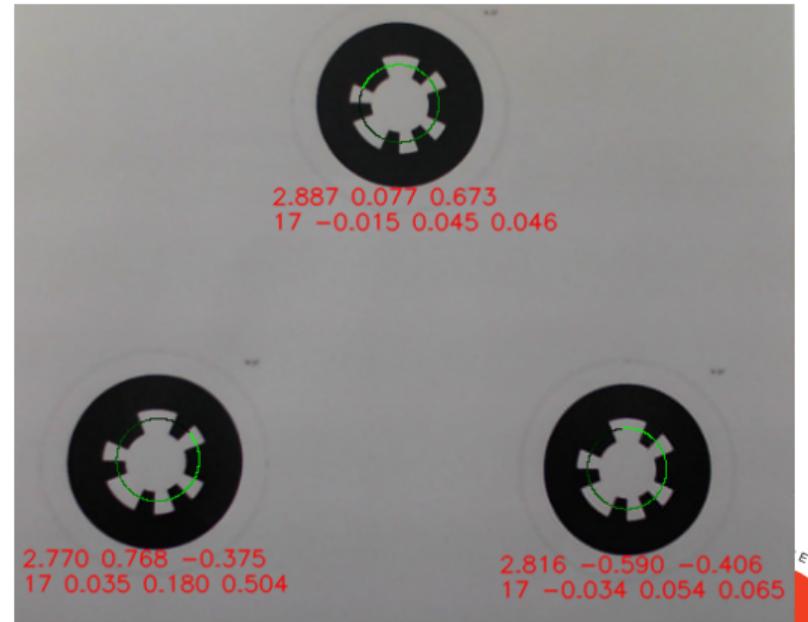
- Original: elliptical sampling through the teeth
- Added: radial sampling at tooth edges
- Takes better advantage of camera distortion



# Fiducial System Modifications: WhyCode

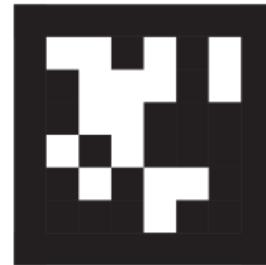
Approach 2: Planar regression from 3+ coplanar markers

- 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.

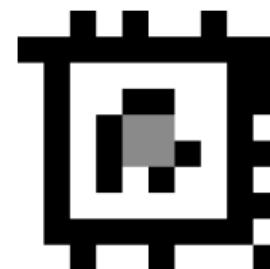


# Fiducial System Modifications: April Tag

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



# 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

