The University of Western Australia

Final Year Project

Computer Vision Chase-Cam UAVs

Author:
Brett Downing

Supervisors:
Prof. Thomas Braunl
Chris Croft

October 2, 2015

Abstract

Multirotors are here to stay, and may soon be expected to interact in a human environment. Commodity quadcopters are advertising capabilities to act as chase-cams and turn-key mapping solutions, but none of the current generation commodity uav chase-cams offer computer vision driven or even assisted flight modes to improve tracking, image framing or obstacle avoidance. Such vision assisted routines would also apply to autonomous or semi-autonomous inspection tasks for fixtures in remote or hazardous environments.

In this project, we build on the results of previous year groups and implement turn-key waypoint navigation and failsafe methods using the ardupilot software stack, and develop robust object tracking, data collection behaviours and exclusion zones on a computationally starved platform with an aim to integrate vision assisted behaviours in low-cost, lightweight UAVs.

In this talk I present our work towards robust, low-cost, computer vision driven object tracking and chase-cam behaviour.

Contents

1 Introduction

Background, Aims

2 History / prior works / relevance

Chase-cam (Lily cam, ...Dog) Cinematography feature films, Red Bull, Remote Inspection, approached by mining industry technology start-ups

3 Motivation

I really really want one. computer vision assisted control routine Obstacle avoidance

Introduction to SLAM systems

4 Project log

4.1 Platform

4.1.1 Description

Frame, Flight controller, processor, gimbal

4.1.2 Platform Weaknesses

(fitness for purpose etc) NAZA not hackable, deliberately obfuscated comms RC switch did not permit altitude control No telemetry Waypoints handled on the embedded system despite GPS loiter behaviour of the flight computer.

4.2 Team Achievements

Conversion to Ardupilot 3.3 Mavlink, waypoints, altidude control, failsafes, telemetry Full, and revocable hand-over to external autopilot. Linearised SI units input and output from flight controller Reduction of mass, tidy wiring harness

Web UI and HUD Waypoint modifier using no-fly zones (not integrated with ardupilot exclusion zones) Glyph detection Capture and tagging of images for proprietary offline 3D reconstruction.

5 Object tracker Theory

5.1 Position estimation

5.2 Desired relative pose

5.3 Observations and uncertainties

5.3.1 Structure from image

Computational load Live capture

5.3.2 Uncertainties

A good uncertainty model encodes what is known and what is unknown. Good treatment of uncertainties combines knowledge without losing information, or adding assumptions. In the case of structure from image, a system that extracts maximal information from a single camera should be automatically capable of full stereoscopy using only the uncertainty analyses that applied to the monocular case. Monocular Camera uncertainty model Lidar Lite Uncertainty model GPS uncertainty model Time evolution uncertainty models Base Utilities Vector sum combination point sample Kalman style filtering Relative uncertainties Networks of relative measurements Graph traversal Nodes: Objects' time history (including self) Survey Markers Assumptions (GPS objects?) Links Relative Observations Motion Estimates IMU data Kalman style interpolation

5.4 Current implementation

5.4.1 Strengths

Encodes appropriate information in a covariance matrix form Cleanly integrates multiple observations into an object model

5.4.2 Weaknesses

Camera model does not account for uncertainty from angle of pixels, gimbal pose, IMU sample time (angular velocity), GPS drift GPS drift is deliberately ignored in favour of applying a generous velocity uncertainty to the objects. Cannot describe complex distributions (unbounded polynomial order) arbitrary geometry Uncertainty Images from SoggyDog

5.5 Future Work

Velocity interpolation not implemented. Graph traversal (SLAM) not implemented. Describe hyperbolic distribution and flaws Describe Laser beam necking case

6 Test Results

6.1 Software tests

Gimbal pose, IMU data, GPS location etc Camera uncertainty models combined with assumptions Pretty pictures Multiple observations with time-evolution

6.2 Live tests

*Able to physically follow one object, while tracking multiple others. Acceleration limits, velocity limits, time-cutoffs. pitch and roll stability Basic colour matching limitations

7 Future Work

Expand uncertainty analysis SLAM, end to end solution SIFT algorithm Optical Flow Recommendations: ROS, ROS, ROS.

8 Conclusions

We have greatly improved the capabilities of the UWA autonomous hexacopter platform, and have brought the code-base up to a level where it is feasible to implement a SLAM process.