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Abhyast Phase V

Semi-Autonomous Aerial Vehicle Design

Boeing-IITK Joint Venture Project

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Proposal:

A quadcopter will be developed which would autonomously map an unknown environment localizing the suspicious object and providing a live feed from scenes.

Abstract:

This paper addresses the problem of autonomous navigation of a Micro Air Vehicle (MAV). We present experimental validation and analysis for our system that enables a quadrotor helicopter, to autonomously explore avoiding obstacles on its trajectory and providing live video feed. Our solution overcomes this challenge in the face of MAV payload limitations imposed upon sensing, computational, and communication resources. In this paper, we analyze the requirements to achieve semi-autonomous stable quadrotor helicopter flight, highlighting the differences between ground and air robots that make it difficult to use algorithms developed for ground robots. We report on experiments that validate our solutions to key challenges, namely a multi-level sensing and control hierarchy, approach to feature identification using open CV (canny edge detection algorithm) and having a semi-autonomous flight avoiding obstacles in its dynamically changing environment.

Introduction

Many researchers have proposed the use of Micro Air Vehicles (MAVs) as a promising alternative to ground robot platforms for rescue tasks and a host of other applications because of their reach. MAVs are already being used in several military and civilian domains, including surveillance operations, weather observation, disaster relief coordination, and civil engineering inspections

Key Challenges

In the ground robotics domain, many algorithms exist for accurate localization in large-scale environments; however, these algorithms are usually deployed on slow moving robots, which cannot handle even moderately rough terrain. MAVs face a number of unique challenges that make developing algorithms for them far more difficult than their indoor ground robot counterparts.

- **Limited Payload:** Limited payload reduces the computational power available onboard, and eliminates popular sensors such as SICK laser scanners, large-aperture cameras and high-fidelity IMUs.
- **Indirect Position Estimates:** While MAVs will generally have an IMU, double-integrating acceleration measurements from lightweight MEMS IMUs results in prohibitively large position errors.
- **Fast Dynamics:** MAVs have fast and unstable dynamics which result in a host of sensing, estimation, control and planning implications for the vehicle. Furthermore, MAVs such as our quadrotor are well-modelled as un-damped when operating in the hover regime.
- **Constant Motion:** Unlike ground vehicles, a MAV cannot simply stop and perform more sensing or computation when its state estimates have large uncertainties. Instead, the vehicle is likely to be unable to estimate its position and velocity accurately, and as a result, it may pick up speed or oscillate, degrading the sensor measurements further.

There are further challenges that we do not address in this work such as building and planning in 2D representations of the environment.

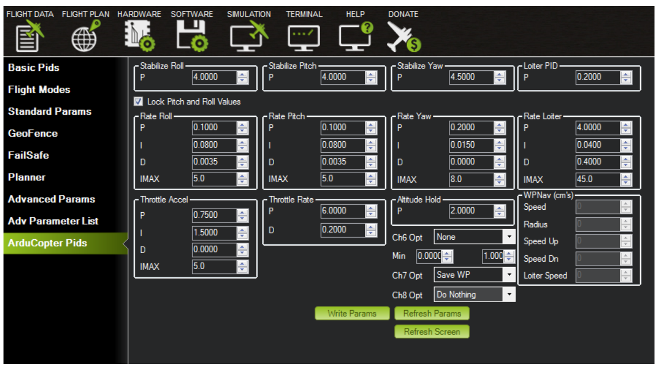
Division of work:

1. Quadcopter Stabilization
2. Decoding Ardupilot
3. Data communication
4. Laser Scanner / SLAM implementation
5. Video capturing:

Quadcopter Stabilization:

Quadcopter controller used is PID controller. Quadcopter is assembled from different part that gave us desired features to quadcopter.

• P-controller – Too much rate P will osciallate quickly, and cause copter to sound angry under stick input. Not enough will not feel sloppy and delayed. Perfect is where it feels locked in, stiff in the air, but not shaky.



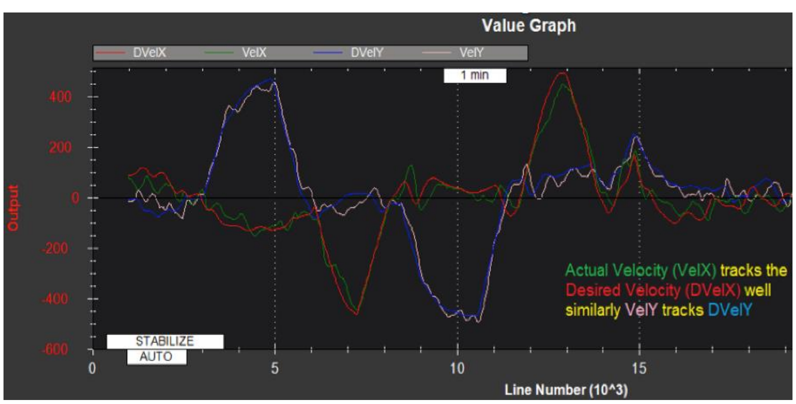
• I controller- Too much rate I will oscillate if you get high enough. Not enough will cause the copter to get pushed by a constant wind. The perfect amount will cause copter to lean gracefully into a constant wind/constant disturbance.

• D controller- Too much rate_D will oscillate very fast. Not enough rate_D will simply mean you can't dial enough rate_P and so you will suffer the effects of having rate_P too low. A perfect rate_D will help fight the wind and follow your sticks as its fast to react.

Flight Modes

Loiter:

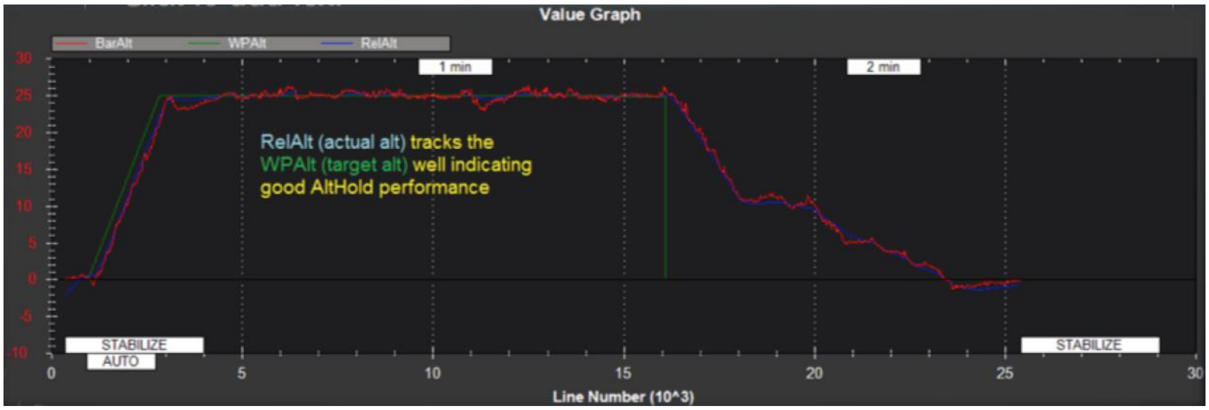
The copter maintains a consistent location, heading, and altitude using GPS , Compass and Barometer. Good GPS position, low magnetic interference on the compass and low vibrations are all important in achieving good loiter performance.



The Loiter PID's P value is used to convert the horizontal position error (i.e. difference between the desired position and the actual position) to a desired speed towards the target position. The Rate Loiter PID values are used to convert the desired speed towards the target to a desired acceleration.

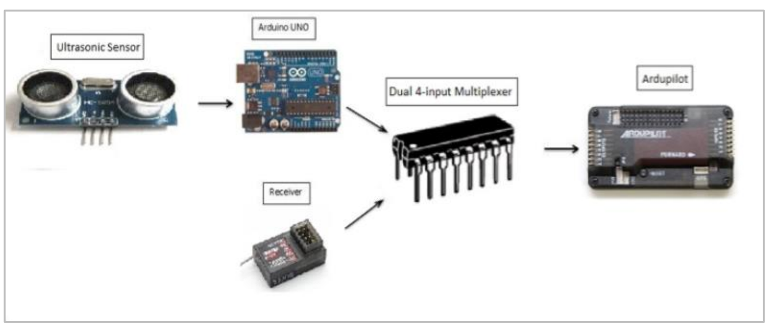
Altitude Hold:

The Altitude Hold PID is used to convert the altitude error (the difference between the desired altitude and the actual altitude) to a desired climb or descent rate. The Throttle Rate PID converts the desired climb or descent rate into a desired acceleration up or down.

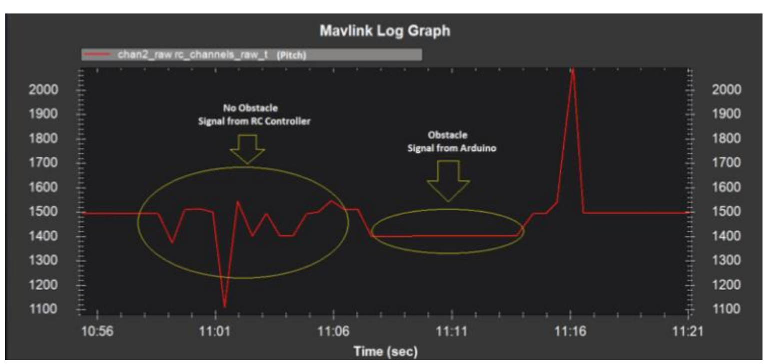


Obstacle avoidance:

Input signal i.e signal from receiver are bypassed by arduino signal to ardupilot when obstacle is observed. And the schematic view of circuit is shown below.



Receiver gets override when obstacle approaches the vehicle.



Live Streaming and Object Detection:

We used Logitech camera to get full HD pictures. Object detection involved capturing of high quality images detecting features along with canny edge algorithm. This technique can be used to detect bombs, brief cases etc.

Initially we used V-sync ssh protocol for information to migrate from quadcopter to ground station. Through this method we tried to get each frame separately and tried to play these frames together at ground station. This process is laggy. SSH protocol has many loop holes like missing data packet sent and no reverse check protocol. All these drawbacks made us to use M-JPEG method. Which is very old way of sending frames from live streaming.

With this we are able to build dynamic database, any device accessing the database through provided link can see the live streaming. We are able to achieve 20fps full HD video with almost no lag at a time for 10 clients.

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