Integrating an Open Source Autopilot with a Quad-Rotor UAV

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Project Goal:

•Produce a UAV system that has the functionality of a commercially available UAV at a fraction of the cost with a greater range of customization and functionality.

•Become familiarized with the installation and operation of the APM 2.5 in order to contribute to both the open source community and the UAF Unmanned Aircraft program.

•To integrate an open source autopilot (APM 2.5) with a commercially available quad-rotor UAV (Unmanned Aerial Vehicle) system, the DraganFlyer X8

Problems:

•Most commercially available UAVs are expensive and are still actively being developed. Cheap systems (~$300) are available yet amount to little more than toys, commercial systems with useful scientific application can cost as much as $100,000.

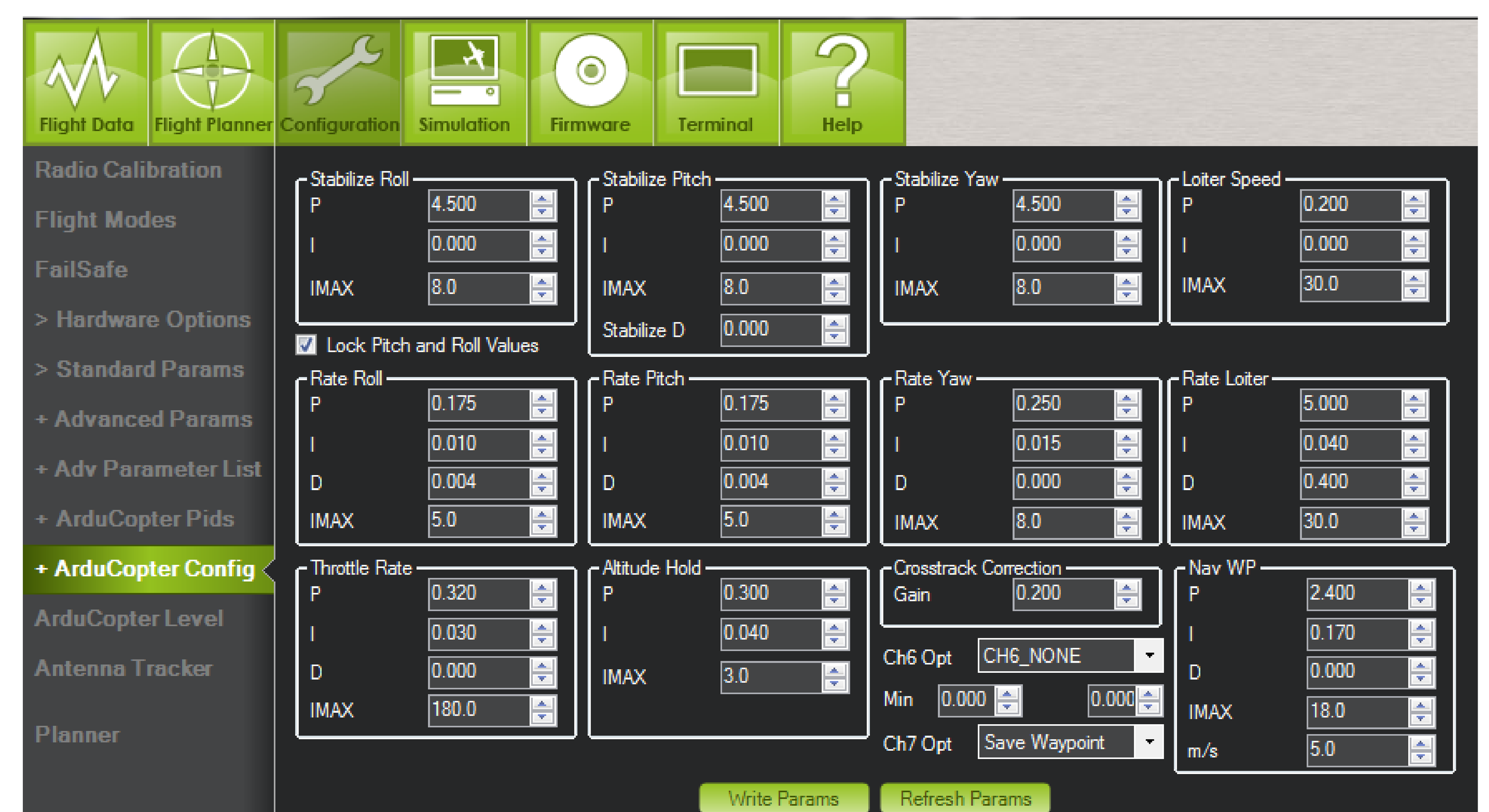
•These expensive systems are used as a black box, you don't know what's going on inside of them. Customization is limited to what the manufacturer makes available to you.

Open source autopilots and UAVs are an alternative to the commercial UAV systems. If development continues they will become very competitive with the commercial products. Since all of the work done on these systems is freely available to the public and contributions from the public are encouraged, the cost of these systems is very low.

Instead of needing a large budget to be able to afford a UAV system, these open source systems are cheap and easy to customize to the specific function desired. Having access to cheap and easy to use UAV systems would give scientists and researchers a powerful tool in gathering data and information.

Fully assembled Quad-Rotor UAV flying with the APM 2.5 autopilot system. Calibration and tuning had to be done in order to achieve a stable flight. During the first flight, using the default flight control settings, the UAV was shaking violently and any control input was so greatly exaggerated that the UAV ended up crashing when it flipped over after being told to "Turn Left". Several more flights would be necessary to attain a stable flight as settings were adjusted and tested.

Ground Station Control program for the APM 2.5 autopilot system. This is an open source program that runs on a laptop that can wirelessly connect to the Quad-copter. It provides a telemetry readout as well as a position overlay on a satellite map. It also provides an interface for the auto navigation feature of the APM 2.5 allowing for real time waypoint navigation. Using the interface, the user can input a series of waypoints to be followed at a specified speed and altitude. The Quad-copter will then autonomously fly the route specified using the preset conditions.



Configuration menu for the APM 2.5 showing all of the vital flight control settings. The APM 2.5 uses a closed loop Proportional-Integral-Derivative, PID, control method where a PID controller reads a sensor and then uses these settings to determine how to adjust motor speeds to attain the desired outcome (e.g. to turn left). These settings being out of alignment caused the small problems in the initial flights (i.e. flipping over and crashing into the ground). Adjusting these settings to the correct values was achieved over several flights where adjustments would be made and their effect on the flying characteristics of the Quad-copter would be assessed. Correct values for these settings are independent to each individual Quad-copter and understanding the effects of these settings is an important part of being able to integrate the APM 2.5 into different flight frames.

Methods

•To stabilize the UAV in flight, we did a series of in field trial and error runs where PID settings were optimized and the effect on handling characteristics were observed
•Automatic Waypoint navigation was tested and calibrated to enable planned route flying and autonomous landing.

IMPACT

Currently UAVs such as this one are expensive and take a large amount of technical knowledge to be able to operate. This project is a step in working towards the final goal of making UAVs a cheap and reliable tool available to anyone who has need of them. UAVs can be sent into areas where it would be too dangerous to send a manned aircraft and can be outfitted with a wide variety of equipment depending on whether it needs to be used to look for gas leaks in the Pipeline, or do low altitude mapping missions. Making this technology cheap and easy to use is vital to opening up the widespread use of this versatile tool.

CONCLUSIONS

•Stable autonomous flight achieved with the autopilot flying a pre-programmed route and automated landing
•Flight duration of 10-12min using a single 4AmpHour battery
•Telemetry range of over 1km using a relatively cheap transmitter.
•Max altitude :170m (feasible to fly much higher)
•Able to hover at a set altitude within a 5m circle
•Determined optimal PID parameters for smooth and reliable navigation

Arducopter Wiki - http://code.google.com/p/arducopter/wiki/ArduCopter2
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