

Arduino Autonomous Robotics System



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Project Purpose

This project is directed toward developing a MAVLINK (Miniature Air Vehicle Link) based LabVIEW ground control system for an Arduino based Miniature Aerial Vehicle (MAV) to successfully complete autonomous missions such as an aerial delivery.

The Arduino platform provides cost effective robotics development and control system with complex sensor arrays. Though there are other ground control software to integrate with the Arduino platform using MAVLINK, our goal is to integrate LabVIEW instrumentation to further enhance the capability of the robot with LabVIEW control and sensors. Our goal is to utilize the Arduino modules in the future robotics because of their low cost. Upon completion, we will be able to implement LabVIEW control of any miniature APM controlled robot working tandem with LabVIEW instrumentation whether it be a ground based rover, helicopter, fixed wing aircraft or even a weather balloon fitted with thrusters.

Logic & Sensors

Aircraft's logic is the 3DRobotics ArduPilotModule 2.5+ with GPS module, altimeter, magnetometer, current sensor and IMUs that includes three axis gyro's and accelerometers.

Communications & Control

The aircraft uses a 900mhz X-Bee serial link to and from the ground control station to relay MAVLINK packets. Every message is double checked from both ends for redundancy and accurate message for safety. The pilot in charge will use a 2.4ghz frequency hopping radio control transmitter to have manual control of the aircraft in case of an emergency.

For first person viewing, the aircraft has a 5.8ghz 600mW video transmitter with circular polarized antennae that transmits video data to the ground station, with a 90 degree field of view pilot CMOS camera tandem with an onboard GoPro video recorder as the main recording camera for later review.

Communication range comes in at an impressive 4km radius line of sight, before significant signal degradation. Further experimentation with amplifiers are required for longer range.

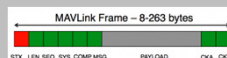
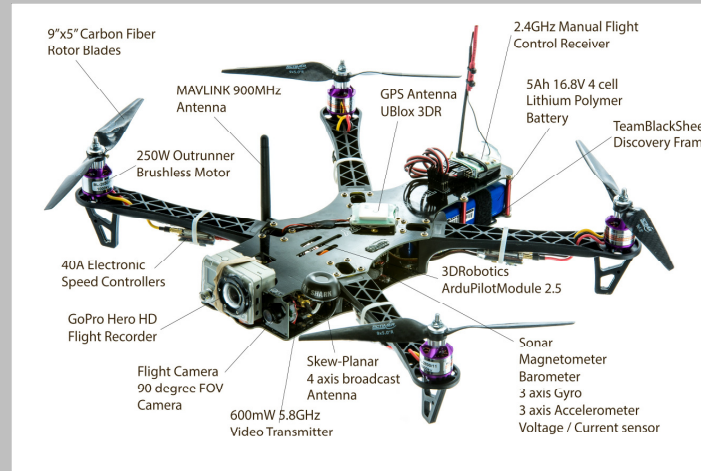
Aircraft's logic is the 3DRobotics ArduPilotModule 2.5 with GPS module, altimeter, magnetometer, current sensor and IMU(Inertial Measurement Unit) that includes three axis gyro's and accelerometers.

Powerplant

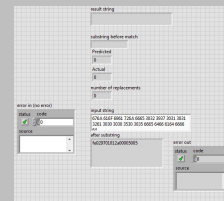
Aircraft is powered by a 16.8V 5Ah 4 cell in series Lithium Polymer battery, powering an electronic speed controller, which controls 28mm x 30mm 11 wind brushless out-runner motor spinning a carbon fiber 9 inch by 5 inch pitch propellers. All of the components are readily available hobby grade RC components. Total aircraft wattage use is about 265W at a hover, and 1130W at full power. The propeller spins in the range of 0-13000 rpm's.

With this high requirement for power, the 75 Amp draw rated 16.8Volt 5Ah battery only powers the aircraft for 8-15 minutes.

Meet Our Robot



MAVLink is a light weight communication protocol designed for small flying autonomous vehicles, with data redundancy in mind. MAVLink was first released early 2009 by Lorenz Meyer under GPL license.



Principles of Flight

A multi-rotor aircraft such as this quad-rotor achieves flight by varying the throttle given to each motor based on the gyro and accelerometer output. Z-axis rotation is achieved by differential torque between opposite rotating rotors. While it maybe flying perfectly still in one location, it is a carefully orchestrated adjustments in each motor's thrust to keep the aircraft level in flight.

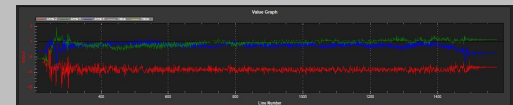
Safety

To assure safety with working on a high power autonomous aircraft, we had to devise and implement a safe way to test the aircraft for airworthiness, vibration analysis and tuning of the PID parameters. With each motor having power in excess of 250watts, thrust ratio of 2:1 with 3kg of total thrust and carbon composite rotors, it required the building of the safety cage to allow for 3 axis movement yet limit the range to perform routine testing and maintenance of the aircraft. Furthermore, additional safety was achieved by implementation of pre-flight and post-flight check list to prevent inadvertent start up of autonomous function which could power up the flight system while servicing. The cage greatly sped up the tuning of the PID parameters to the airframe for ideal control and stability.

Getting the Aircraft Airworthy

The challenges of any autonomous aerial vehicle is its flight characteristics. It is a simple concept but with four motors controlling its attitude through the air, it must be flown manually first to ensure the vibrations and sensor outputs are within the acceptable range before it can be attempted to be flown autonomously.

We had to take a range of vibration reduction measures, including balancing the propellers on magnetically suspended rod, and mounting the flight controller on memory foam. By using the commercially available Mission Planner 1.2.45 ground control software we were able to make the aircraft autonomous flight ready.



Progress

We were able to assemble the aircraft, achieve stable flight, and complete the robots first autonomous flight using the QGroundControl.org's mission control. Now we have been able to intercept, filter and verify incoming MAVLINK packets by using LabVIEW to decode the messages. We are now looking at integrating the functionality of transmitting customized messages for the autonomous system to execute with LabVIEW.

Conclusion

The difficulty in integrating the MAVLINK protocol into LabVIEW has been identified. This was caused by the open-source nature of the third party software, being written in many different types of programming languages.

Current PID adjustments still requires a lot of adjustments and testing due to the overshooting of target altitude and GPS location.

Coding the MAVLINK into LabVIEW is our next focus for our research, with partnership with the Computer Science Department. This will be the bread and butter of the system, promising the future of Arduino powered, LabVIEW controlled, MAVLink enabled robotics at the UW-Eau Claire at much lower initial cost.

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