MicroCART

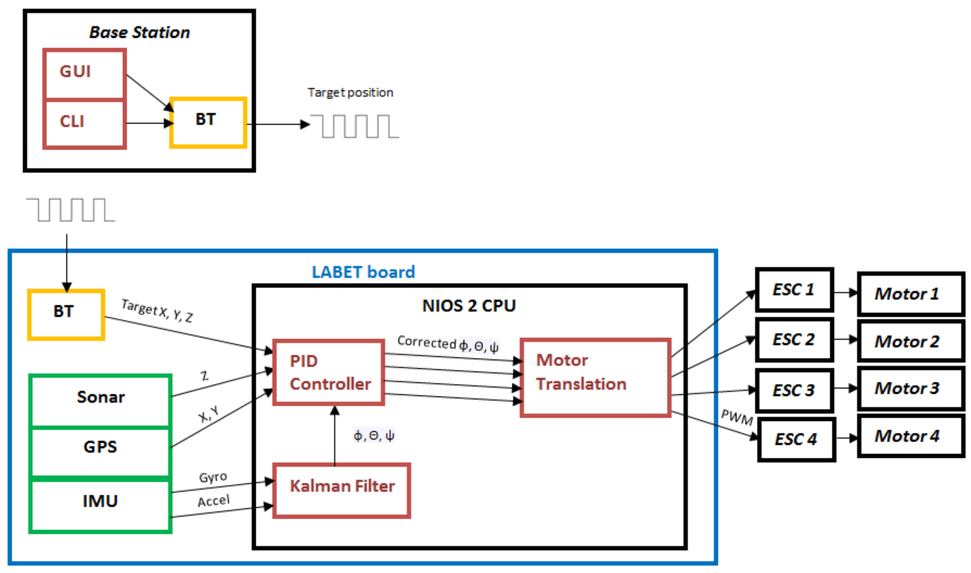
May 14-10

Microcontroller Controlled Aerial Robotics Team

Introduction

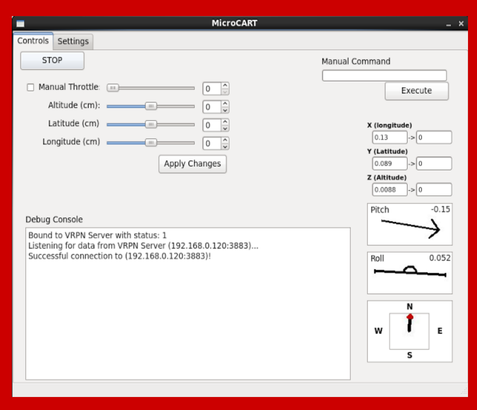
MicroCart is an ongoing senior design project for electrical, computer, and software engineers at Iowa State. The task of the 2014 team was to build an autonomous quadcopter, or “quad”, using on-board microcontroller and sensors. The key hardware devices used are an Infrared (IR) camera system acting as pseudo-GPS and a custom-designed board mounted to the quad which contains an IMU (Inertial Measurement Unit) for obtaining orientation, a bluetooth module for sending commands, and a FPGA (Field-Programmable Gate Array) programmed with a CPU for in-flight computations. The key pieces of software used are the PID controller for quad stabilization, the Kalman filter for optimal orientation estimations, and a signal mixer to control each motor.

Design Diagram



GUI

The User Interface is designed to give the user basic control over the vehicle. It allows the user to set position targets for the quad, as well as to be constantly updated to the vehicle's current whereabouts, such as current orientation and position. The UI supports the Bluetooth protocol, and allows the user to both fly manually as well as automatically.

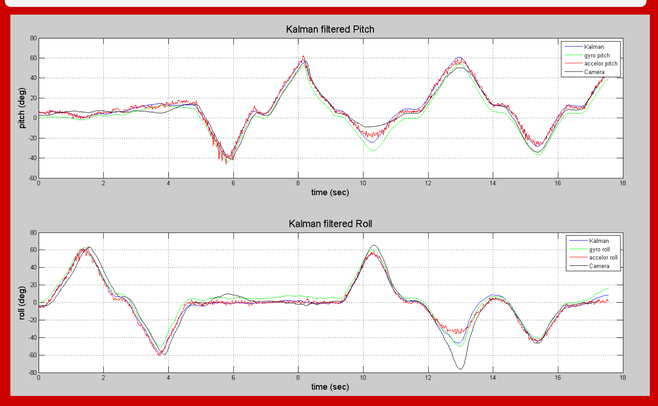


Bluetooth

Bluetooth communication is used to send commands from the base station computer to the FPGA on the quad. These commands range from pitch and throttle to target coordinates. The packets are guaranteed using cyclical redundancy checks and start bytes are used to ensure consistency.

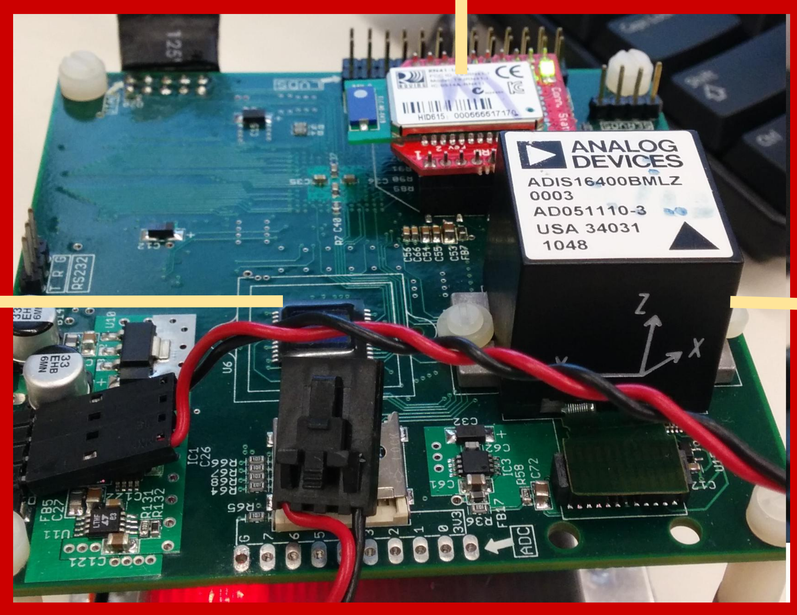
Kalman Filter

The Kalman Filter combines the best parts of gyroscope and accelerometer data from the IMU to produce a more accurate estimate of the orientation than either would alone. This is necessary due to accelerometer noise and gyroscopic drift. The Kalman Filter is a recursive weighted average filter that estimates a reliable orientation of the quad based on a state transition algorithm.



PID Controller

The Proportional Integral Derivative (PID) controller is the main part of the closed-loop system that acts to control the quad’s movements autonomously while in flight. Our implementation contains nested PID controllers: the outer loop is a position controller, the inner loop is an orientation controller. An error in position creates an error in the orientation. This error will cause the quad to pitch or roll until the position error becomes zero. Finally, the resulting new values of throttle, roll, pitch, and yaw are sent to a signal mixer to control each motor.

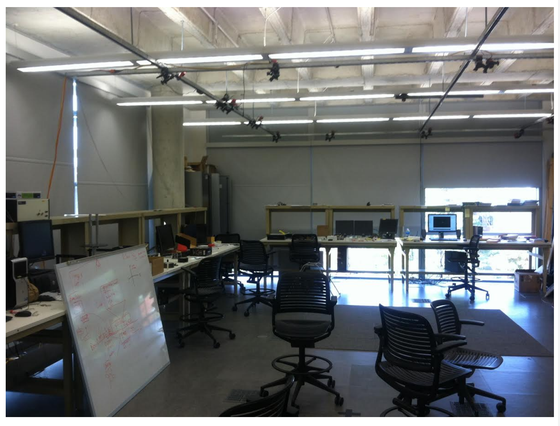


IMU

The inertial measurement unit (IMU) provides us with data from 3-axis accelerometer, 3-axis gyroscope, and magnetometer. The sensors provide raw data for roll, pitch, yaw, and movement directly to the quad without the issue of time delay. These angles are used with the PID controller to stabilize the quad.

Resources

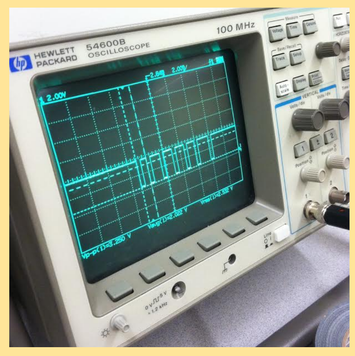
The key resources we used were datasheets for interfacing with hardware devices and open-source code on related projects. The quad, PCB board, and camera system were provided at the start of the project. Smaller hardware components were ordered. The most valuable resource was our time. Total Hours after 25 weeks: 1202



Our own lab as seen above, complete with limited access and equpiment.

Testing

Since most of the project was testing, we needed a solid testing plan to make sure the project would be successful and the vehicle wouldn’t crash during flight. The different tests ranged from hardware connection and mobility testing to correct output values from the code.
In order get precise data from each flight test we created a “checklist” method consisting of safety and setup checks. This method proved itself in producing precise data during both semesters of testing. The vehicle also had to go through waveform tests before any flight could be logged to make sure the code was outputting the correct values.



Client& Advisor

Dr. Nicola Elia
Dr. Phillip Jones

Team Members

Kevin Engel
Michael Johnson
Nathan Ferris
Kelsey Moore
Aaron Peterson
William Franey
Lucas Mulkey