Microprocessor-Controlled Aerial Robotics Team

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Department of Electrical and Computer Engineering

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The Problem

- Vehicle contains black box components
- No further room for development
- System has slow feedback response

Solution

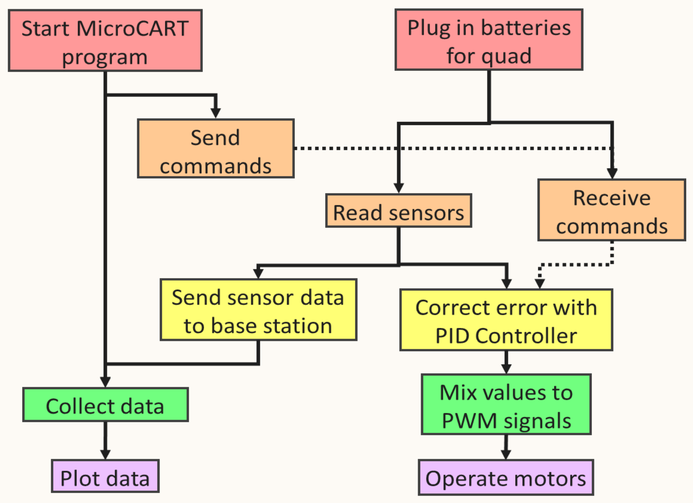
Build a new quadcopter with

- Programmable board and peripheral ports
- On-board sensor and feedback control
- On-board signal mixing for motors

Intended users

- Cooperative autonomous robotics research
- Undergraduate controls or embedded systems courses

System-Level Diagram



Testing

Environment

Coover 3050 Lab, OptiTrack IR Camera System

Procedure

1.Function and unit test each component

2.Test output signals from components using oscilloscope

3.Find latencies or bottlenecks, if any

4.System test the component on the quad body

Resources

Total Budget: $3087

Total team hours: 1286

Average hours per team member: 160.75

Quadcopter Body (Structure)

The core frame of the quadcopter that is sturdy and able to carry all peripherals, sensors, and actuators

Constraints

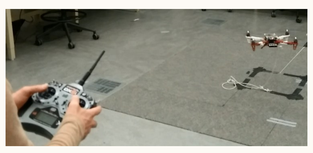
- Must maintain lightweight load
- Balanced center of gravity

Safety

The quadcopter has to be capable of taking a fall while not damaging any of the on-board equipment

Product

DJI Flamewheel F450



Batteries & Regulators (Power)

Needed to power the quadcopter motors, processing board, and peripherals

Voltage Restrictions

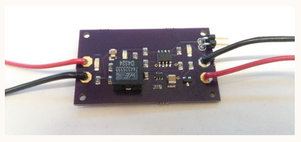
Main processing board requires input voltage from 4.5-5.5V

Custom Regulators

- Drop down voltage
- Prevent over discharging and reverse polarity
- Indicate when batteries reach low limits

Products

- Hyperion 11.1V 3-cell LiPo Battery
- Hyperion 7.4V 2-cell LiPo Battery



Motors & ESCs (Thrust)

Responsible for generating thrust and allowing the quadcopter to fly

Speed

- Electronic Speed Controllers (ESCs) work at 450Hz
- Motors able to get up to 10,000rpm

Propellers

- Several types made out of plastic or carbon fiber
- Balanced propellers reduce vibration and noise

Products

- DJI 30A OPTO ESCs
- DJI Brushless Motors

Zybo Board (Computing)

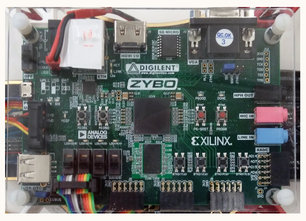
- Collects measurements from sensors
- Calculates controller corrections
- Mixes signals for the four motors
- Outputs Pulse Width Modulations (PWMs) to ESCs

Expandability

The board has a Field Programmable Gate Array (FPGA) and multiple peripheral ports to program

Product:

Diligent ZYBO - Zynq 7000 Development Board



Sensor Board (Sensing)

Measures gyro, accelerometer, and magnetometer data

Specs

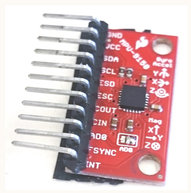
- Uses I^2C communication protocol at 400kHz
- 1kHz accelerometer and 8kHz gyro sample rates
- Digital low-pass filters for reducing noise

Challenges

Connection issues between the sensor and the Zybo board caused the quad to lock up in early stages of development

Product:

SparkFun 9 Degrees of Freedom - MPU-9150



Bluetooth (Communication)

- Receives control commands
- Sends sensor and calculated data from the quad

Communication Protocol

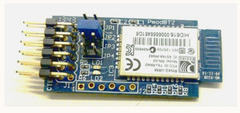
- Operates at 921,6000 baud rate
- Uses minimal data packets to increase throughput

On-board Tuning

Bluetooth was essential during the control tuning process by receiving commands to change coefficients or setpoints

Product

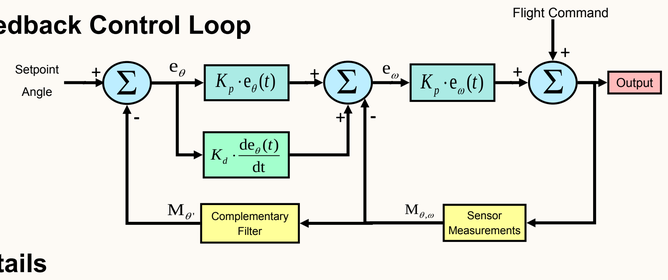
PmodBT2 (RN-42) - Bluetooth Interface



PID Controllers (Controls)

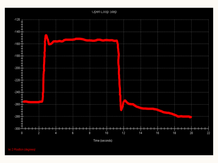
- Adjusts flight commands to compensate for error
- Calculates error using ideal and measured position or speed

Feedback Control Loop



Details

- Uses an inner (speed) and outer (position) PID for better stability
- Tuned using angular momentum machine, single axis stand, and 3-axis stand



Software (Logging)

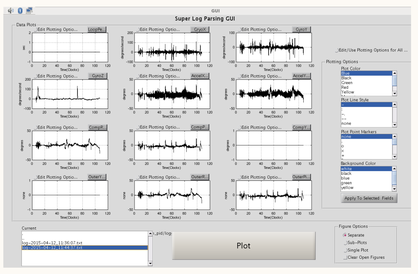
Ground Station Flow

1.Establishes communication with the quadcopter

2.Sends commands or external data to the quadcopter

3.Creates logs of data received from quad

4.Visualizes data after each flight



Tools

Bash scripts, C/C++, MATLAB, QT library

Client & Faculty Advisors

Dr. Phillip Jones

Dr. Nicola Elia

Team Members

Joe Boldrey, Adam Campbell, Paul Gerver, Tyler Kurtz, Jacob Rigdon, Ravindra Nagaraju, Matt Post, Matt Vitale

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