IOWA STATE UNIVERSITY
Department of Electrical and Computer Engineering

MicroCART
May 17-16

Microprocessor Controlled Aerial Robotics Team

Introduction

Project Statement: *To create an aerial robot as a modular platform for research in controls and embedded systems.*

Intended Users

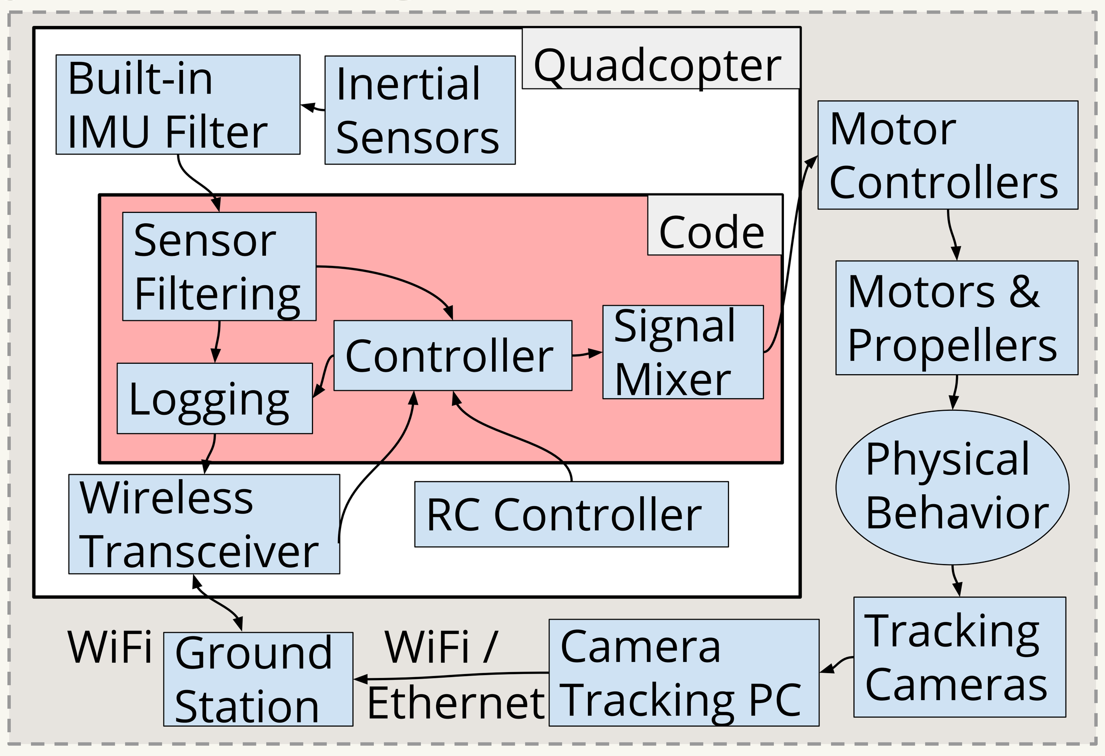
- Controls students who want to experiment with and test different control structures
- Controls research graduate and PhD students

Goals

- Autonomous flight with waypoint navigation
- Independence from camera system
- Develop a mathematical model of quadcopter

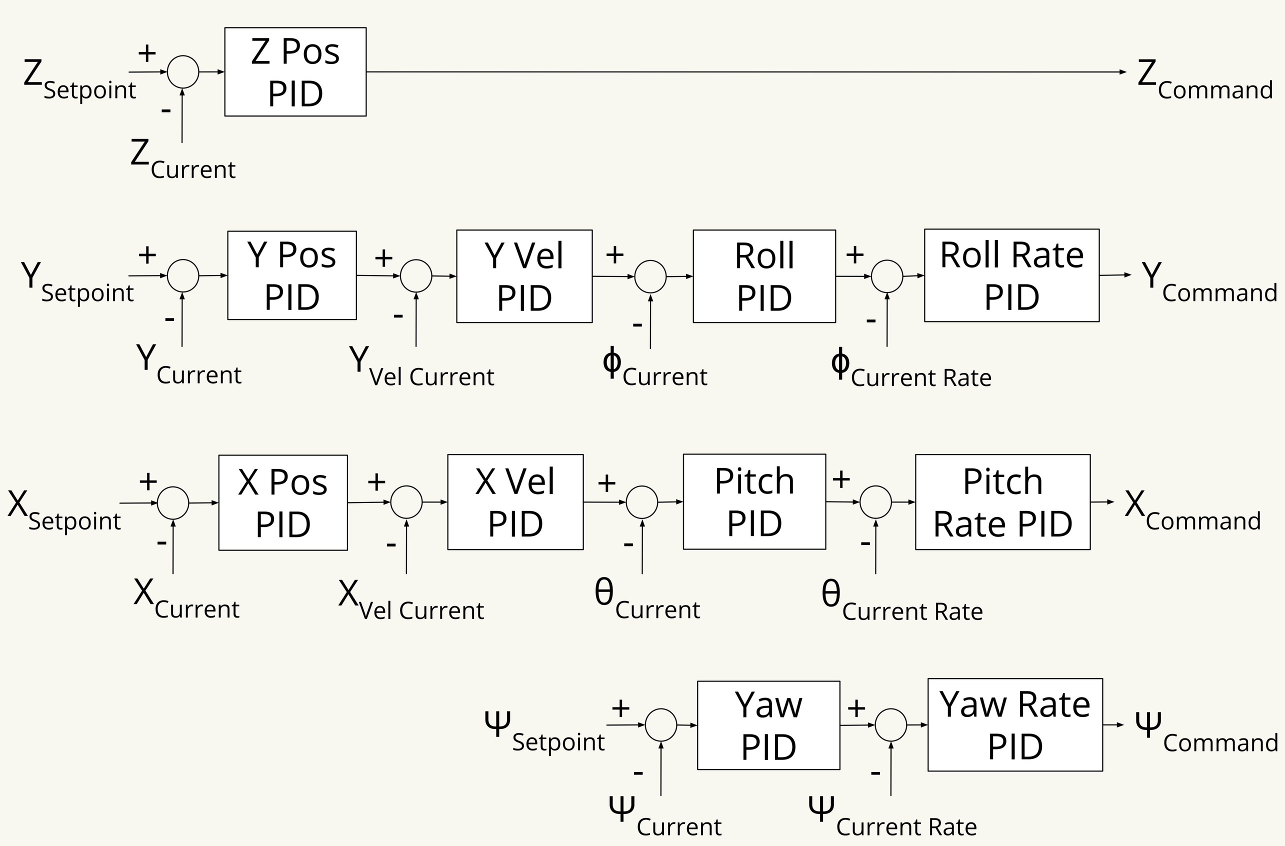
High level Diagram

System Diagram



Mathematical Model and Control Structure

- Created Simulink model of physical quadcopter and sensors
- Designed control structure around this open-loop model of the system
- Added ability to insert signals and log signals at any point in model

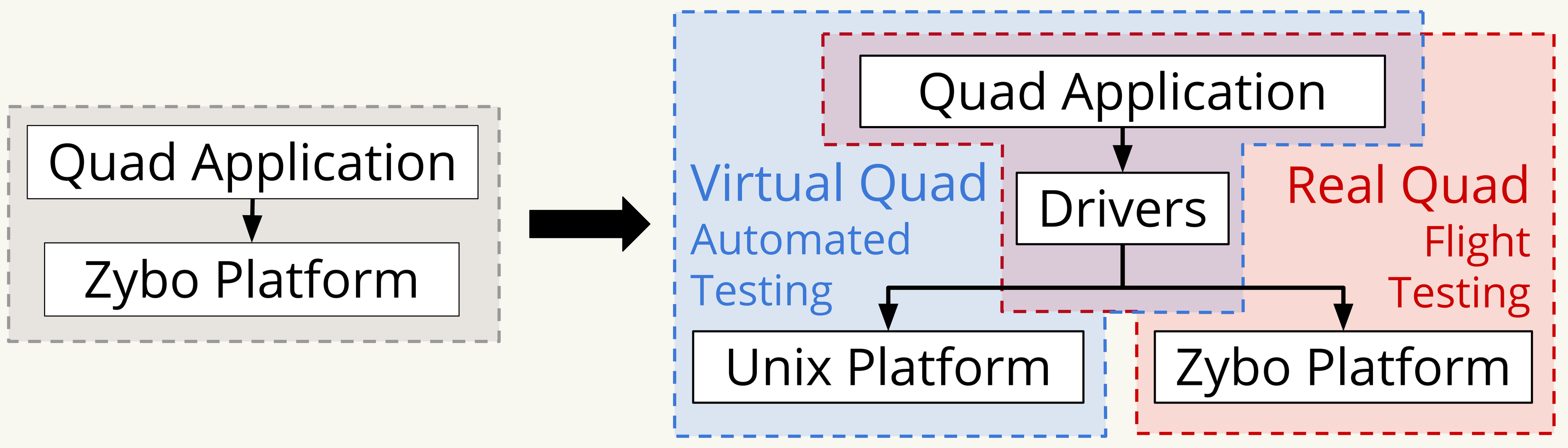


- Four parallel position movement options:
  - X-axis (Latitude)
  - Y-axis (Longitude)
  - Z-axis (Altitude)
  - Yaw
- Nested PID structure
- Added X and Y Velocity PIDs to original design
- Filtered derivative terms

Software Designed for Testing

Problem: Quad application was tightly coupled to the Zybo platform, forcing us to exclusively use end-to-end testing, slowing down the development process.

Solution: Re-design software using interface-like drivers, enabling us to run the application on any platform, including a Unix environment we use for unit and functional testing.



Original Testing Strategy

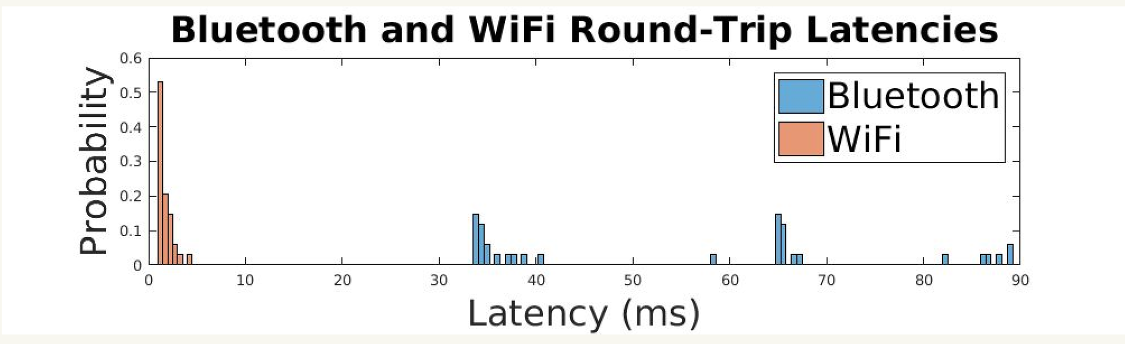
- End-to-End testing

New Testing Strategy

- Unit/Functional Testing (Continuous Integration)
- Dedicated Hardware Tests (Manual Scripts)
- End-to-End Testing

Communication

- Quadcopter
  - ESP8266 converts between WiFi and UART
  - Async UART connection to ESP8266
- Ground Station
  - TCP connection by backend
  - Reliable stream to backend
  - Backend handles client multiplexing with Unix domain socket

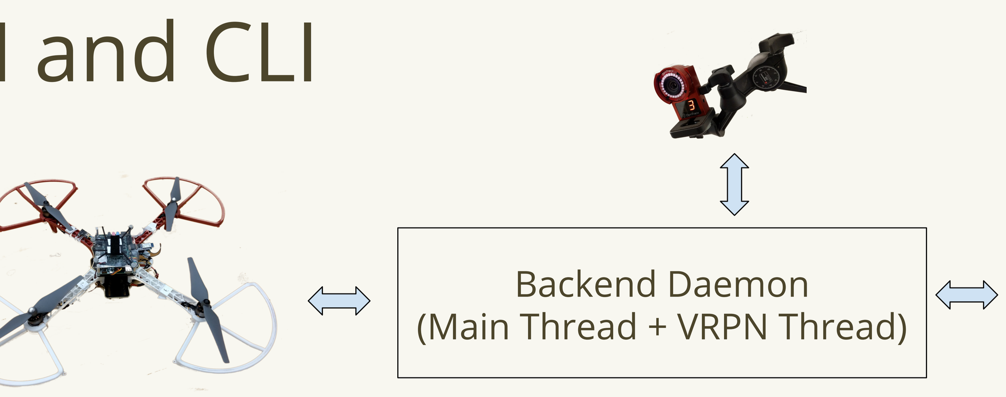


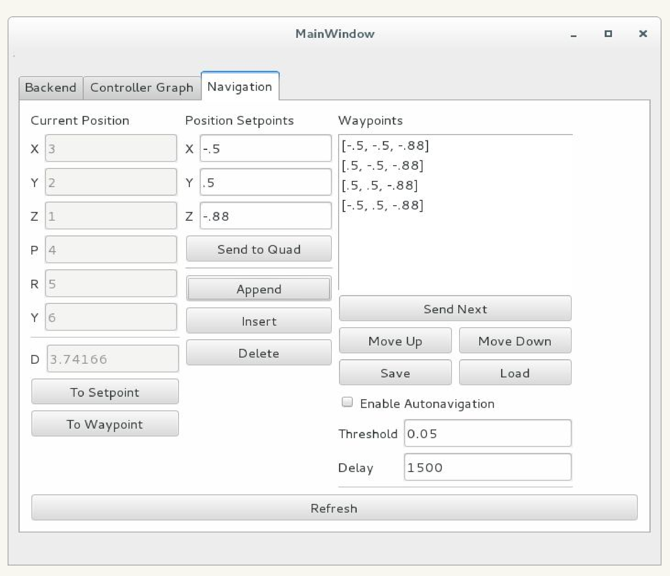
Added Capabilities

- Agnostic Height Sensing
  - Accomplished through LIDAR, a laser-based proximity sensor
- Stable Autonomous Flight
- Waypoint Navigation
- Automatic takeoff and touchdown

Lidar Sensor

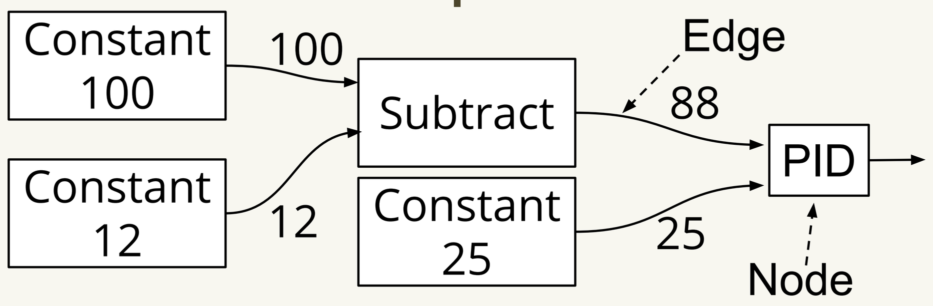
GUI and CLI





- Backend Daemon
  - Manages quad connection and tracking system
- Decoupled Frontend
  - GUI or CLI
  - Monitor quad position and orientation
  - Modify control structure
  - Send quad waypoints and navigation commands
  - CLI provides access to full functionality and scriptability

Directed-Graph Based Calculations



- Each computation resides within a single node.
- Output can be calculated via a depth-first search.

Applied to the Control Structure

- Advantages
  - This allows the controller to be easily reconfigured without modifying software
    - Can be modified from the ground station in real-time
  - Each node has a well-defined function, increasing testability and extensibility
  - Controller can be visualized in the GUI

Team Members

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