MicroCART Mini

sdmay25-32

Daniel Zaucha, Ryan Lowe, Yi Hang Ang, Jonah Upah

Client & Faculty Advisor: Dr. Phillip Jones

Team Website: https://sdmay25-32.sd.ece.iastate.edu/

Project Overview

MicroCART: Microprocessor Controlled Aerial Robotics Team

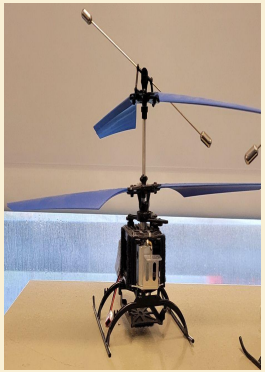
- Design mini quadcopter platform to be used in CPRE 4880 and for Controls & Embedded Systems researchers
- Develop mini quadcopter printed circuit board (PCB), containing a Microcontroller, RF, IMU, and Wi-Fi chip
- Develop software to stabilize and communicate movements
- Develop base-station to communicate with quadcopter
- Create and improve documentation and video tutorials for future teams

CrazyFlie micro-quadcopter

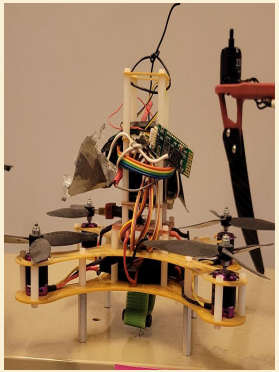
Project History

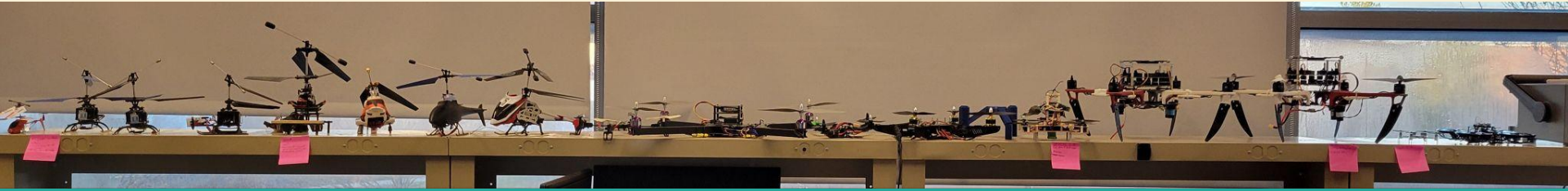
- Project began in: 1998 - Now
- Current iteration began in 2018.
  - Open source crazyflie software
  - Student designed test-stand
  - Project YouTube channel

Current Implementation



Last Quad
--------->
First Copter
<---------





Users

- **CPRE 4880 Students**
  - Lab 4
- **Successor Project Team**
  - Next years MICROCART team
- **Project Advisor/TAs**
  - Dr. Jones, TAs assisting with Lab 4
- **Prospective ISU students**
  - People observing our demonstrations

User Project Desired Outcomes

- **488 students**
  - Gain a deeper understanding of PID controllers and embedded programing.
- **Future MicroCART teams**
  - Take what previous groups have accomplished and optimize or create new features.
- **Advisor/TAs**
  - Help guide students through Lab 4 with the use of documentation from the MicroCart team.
- **Potential ISU students | Scholar's Day 2025**
  - Individual larger drone project design. The drone will be used as a demo at college fairs and touring highschool students.

Functional Requirements

- **Mini Quadcopter should be able to:**
  - Fly smoothly
    - Flight stabilization
    - No sudden “random” movements
    - Quick reactions to directional inputs
  - Connect to remote equipment for data analysis
  - Be able to connect to remote sensors and utilize the information to fly
  - Be utilized easily even by someone with no prior experience in controlling any remote control vehicle
- **Frontend/Backend should be able to:**
  - Display data from flight information
  - Be able to enable an uncontrolled flight via sensor data

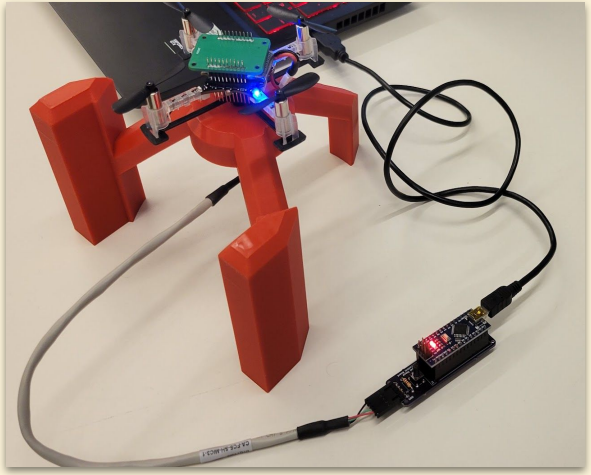
Non-Functional Requirements

- **CPRE 4880 Lab 4**
  - Creating / improving lab documentation for use in CPRE 4880
  - Organize virtual environment

- **Future MicroCART Teams**
  - Recording and uploading tutorials to the MicroCART YouTube channel to demonstrate/explain tools associated with the quadcopter
  - Updating and adding documentation to the MicroCART Git repository that is passed on to each new team
  - Improving bootcamp to help new team members get up to speed quicker

Technology Considerations

- **Virtual Machine**
  - Project environment and means of deployment
  - GUI & remote connection
- **BitCraze - CrazyFlie mini quadcopter models**
  - Open source software and hardware for CrazyFlie
- **Network technology / Radio Communications**
  - The communication pipeline, UNIX sockets
- **Microcontrollers/Low-level programming**
  - Drones onboard software
- **PCB fabrication**
  - Battery retention

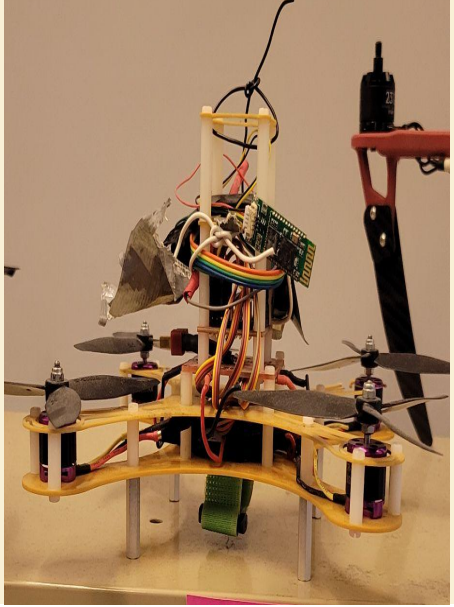


Powered on Crazyflie locked into the test stand communicating with the computer

Radio Dongle

Market survey

- **Unique features:**
  - Custom client for setting drone parameters.
  - Custom plots for monitoring drone data.
- **Existing solutions: (Implemented after 2018)**
  - BitCraze open source platform:
    - CrazyRadio hardware
    - CrazyFlie hardware
    - CrazyFlie API software



Potential Risks & Mitigation

- **Backend framework (low risk)**
  - Bugs created while optimizing code would hinder students' progress in Lab 4
  - Mitigation: Do incremental solutions, Git version control

- **Deployment (high risk)**
  - Deployment of the VM containing our revisions, issues would cause a huge setback for CPRE 4880
  - Mitigation: Complete Lab 4 as a test before deployment

Continual Maintenance Resource/Cost Estimation

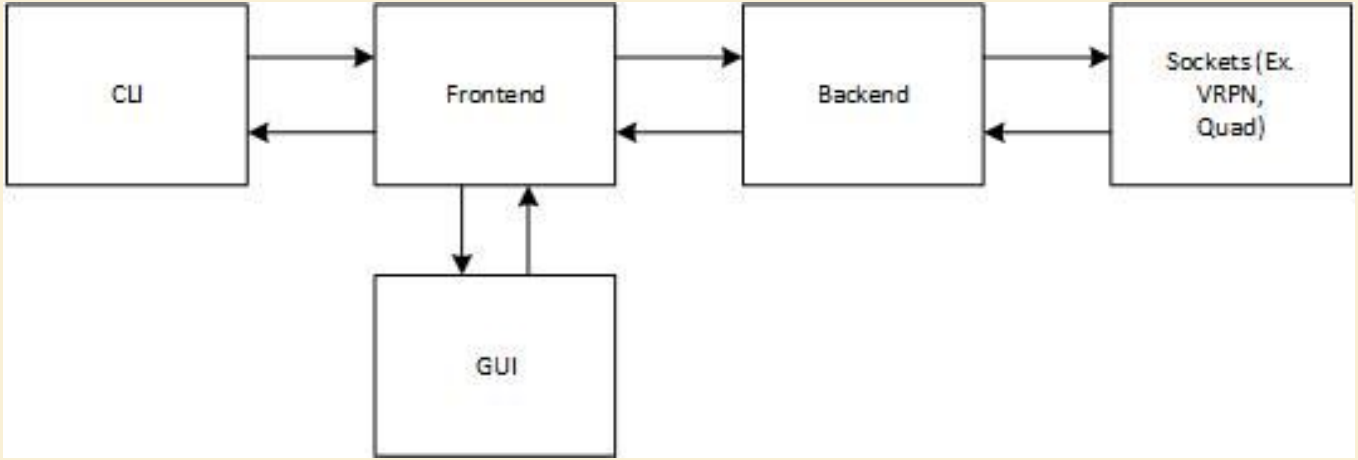
- Expected: x12 sets of working lab components
- Single set:
  - CrazyFlie
  - 2x Batteries
  - Crazyradio

Parts	Amount	Cost
On button (B3U-3000P)	x3	$1/unit (Bundle Price flux) $3
Crazyradio PA 2.4 GHz USB dongle	x6	$38/unit $228
Battery	x18	$3.20/unit | $2.24/ unit (x10 bundle) $44.80 (2x Bundles)
Budget: $500	Total Cost: $272.80	Remaining Budget: $227.20

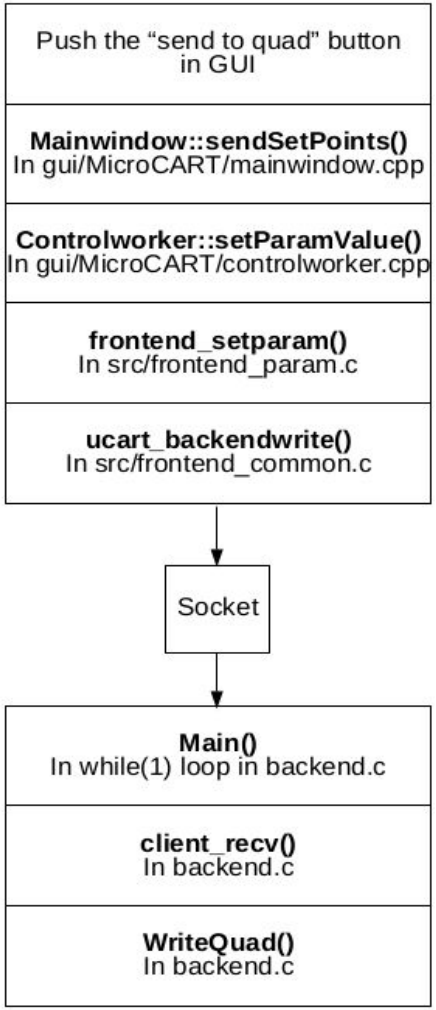
Project Schedule Fall Semester

Software Design

Big picture ground station:

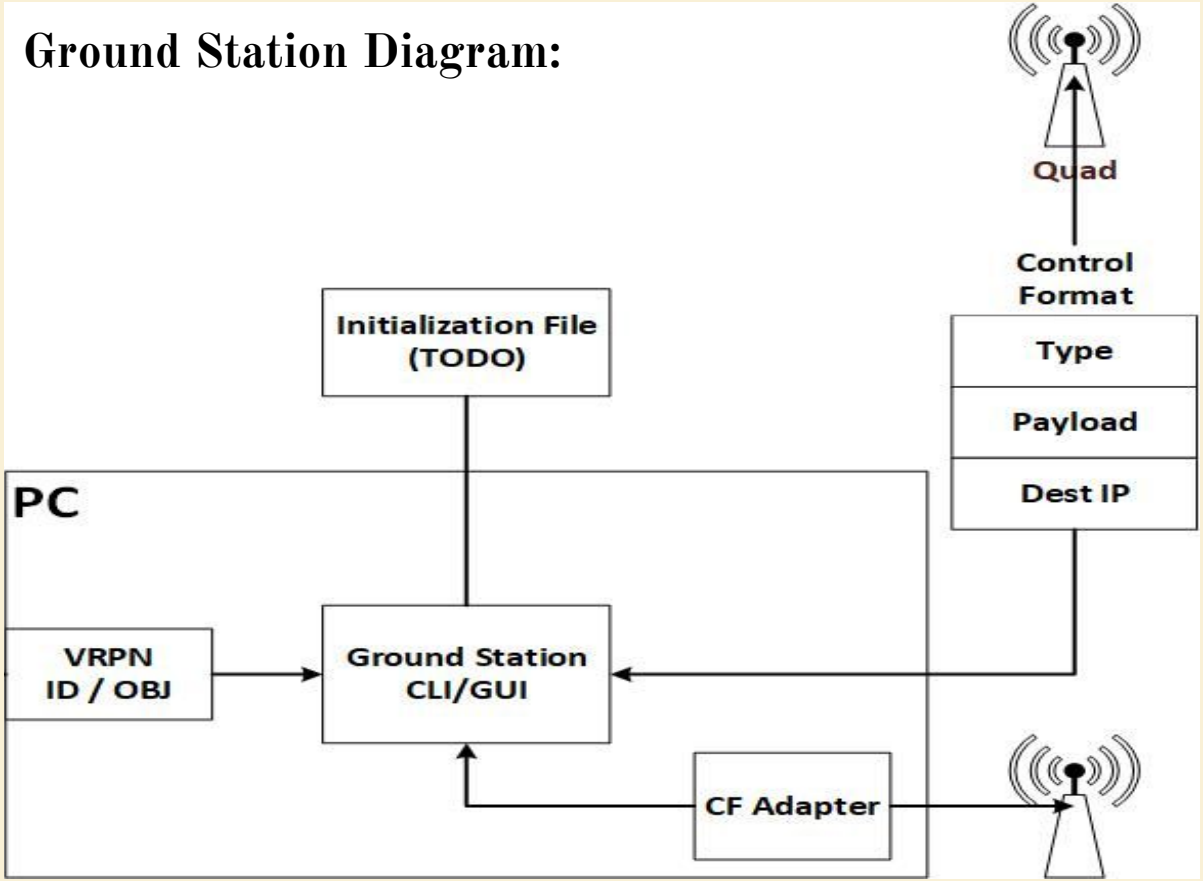


Ground Station Call Stack:



Software Design (Cont.)

Ground Station Diagram:



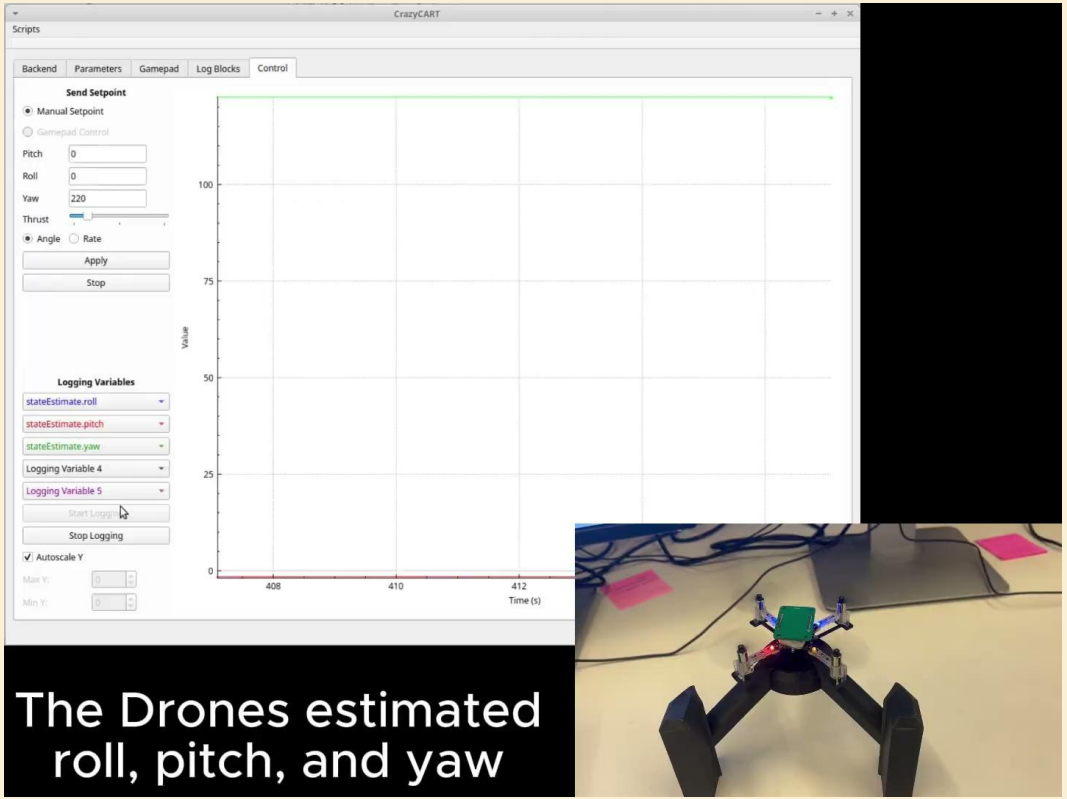
Technology Platforms used

- **Bitcraze**
  - CrazyFlie quadcopter
  - Crazy radio
  - Cflib library
- **Oracle VM VirtualBox**
  - Virtual Machine
  - Linux
- **GitLab**
  - Version control
- **Qt**
  - GUI

Testing

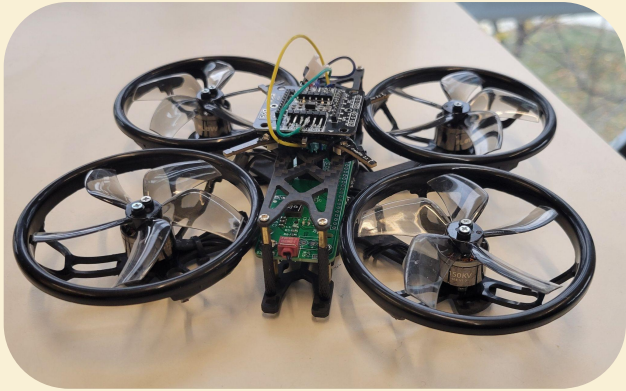
- **Unit Testing**
  - Test all software components in the frontend and backend using print statements and outputs
- **Interface Testing**
  - Thorough testing of the backend and frontend communication that is done via UNIX Sockets
  - Print statements after each process sends or receives a message
  - Output data to file to ensure data is being passed correctly
- **System Testing**
  - Test entire system by walking through the lab 4 and complete testing without errors or bugs
- **Regression Testing**
  - When adding new pieces or making improvements, make sure existing functions still work
- **Acceptance Testing**
  - Ensure approval from our client Dr. Jones
  - Receive feedback from students regarding lab 4 to make improvements

Demo


CrazyCART
Scripts
Backend
Parameters
Gamepad
Log Blocks
Control
Send Setpoint
Manual Setpoint
Gamepad Control
Pitch
0
Roll
0
Yaw
220
Thrust
Angle
Rate
Apply
Stop
Logging Variables
stateEstimate.roll
stateEstimate.pitch
stateEstimate.yaw
Logging Variable 4
Logging Variable 5
Start Logging
Stop Logging
Autoscale Y
Max Y:
Min Y:
100
75
50
25
0
Value
408
410
412
Time (s)
The Drones estimated roll, pitch, and yaw

Conclusions

- **Upcoming plans**
  - Test stand
  - Implement code to enable custom quadcopter to fly
  - Continue improving documentation
- **Individual contributions**
  - Jonah: Backend mapping, Test stand integration to backend.
  - Ryan: Backend assistance, work with packets
  - Daniel: Frontend assistance, Documentation updating
  - Yi: Frontend coding, backend assistance



Works Cited

- Jones. “CprE 488 - Embedded Systems Design.” Iowa State University, https://class.ece.iastate.edu/cpre488/schedule.asp
- Zambreno. “491_Final_Presentation.” Iowa State University, https://seniord.ece.iastate.edu/resources/491_Final_Presentation.pdf