

IOWA STATE UNIVERSITY

MicroCART | sdmay23-45

Project Review

Team members: Austin Beinder, Cole Hunt, Tyler Johnson,
Gautham Ajith, Emily Anderson, Grant Giansanti, Connor Ryan
Advisor: Dr. Jones

Team 45



Grant Giansanti
User Interaction/Testing



Tyler Johnson
Project Manager



Connor Ryan
Physical Systems Lead



Austin Beinder
Simulation/Controls Lead



Gautham Ajith
YouTube/GUI Lead



Cole Hunt
Git Master/Device OS



Emily Anderson
Backend/Telemetry Lead

MicroCART

Microprocessor Controlled Aerial Robotics Team

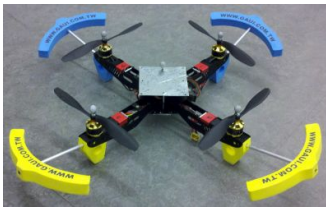
- MicroCART Project has been around since 1998.

Use Cases

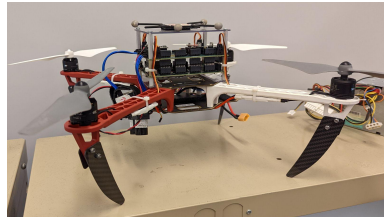
- Iowa State Classes
 - CPRE 488 Embedded System Design
 - EE 476 Control System Simulation (maybe in the future)
- Research
 - Controls



Team 2009



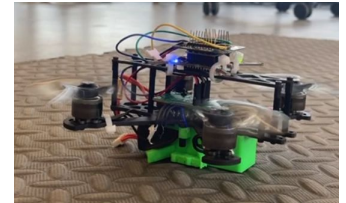
Team 2013



Team 2015



Team 2022 *crazyflie



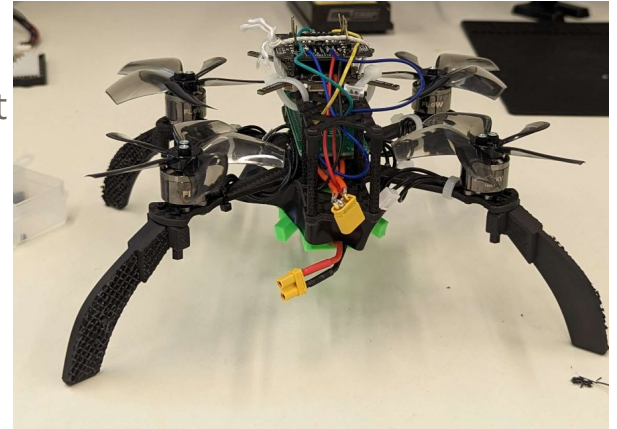
Team 2023

Introduction - Goals and Vision

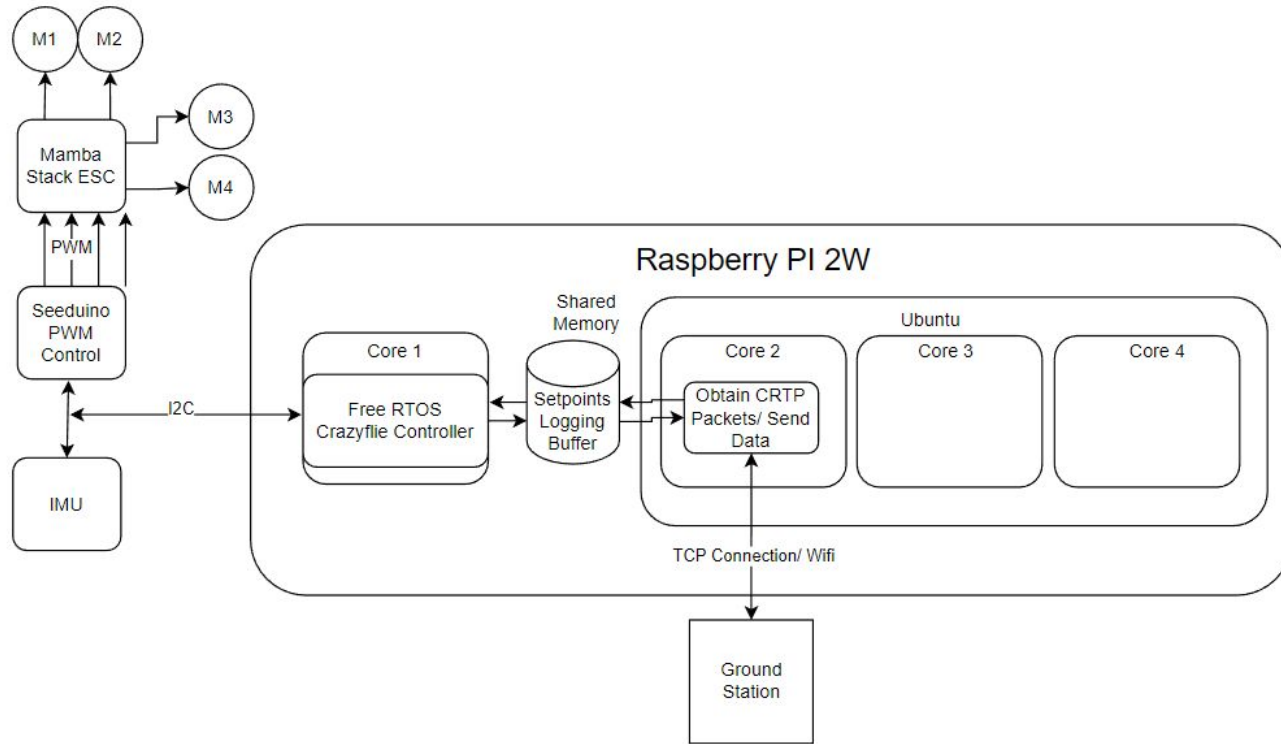
- Develop a quadcopter for control theory research requiring multi-core functionality
- Improve existing lab materials and documentation for CPRE488: Embedded System Design
- Create demonstration for potential students utilizing MATLAB quadcopter simulation
- Produce YouTube tutorials explaining to undergraduates the toolsets and processes related to our quadcopters

New Quadcopter-"FlyPi"

- Develop processes related to our quadcopters
- Requirements
 - Relatively small form factor
 - Controlled with crazyflie firmware as a starting point, flight controller on Raspberry Pi 2W
 - Utilize multi-core functionality of 2W for future advanced control algorithms
 - Brushless motors
 - Support open-source expansion decks
- Intended Users
 - Future MicroCart Teams
 - Grad student controls researchers



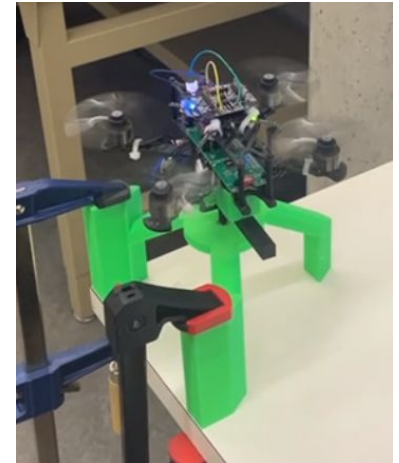
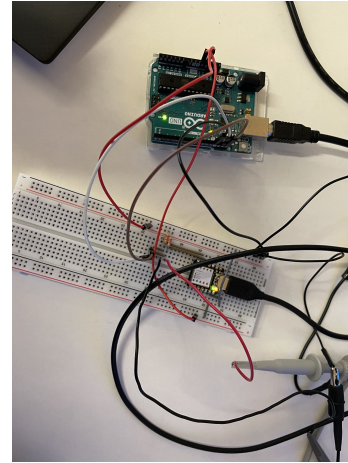
FlyPi Block Diagram



FlyPi Retrospective

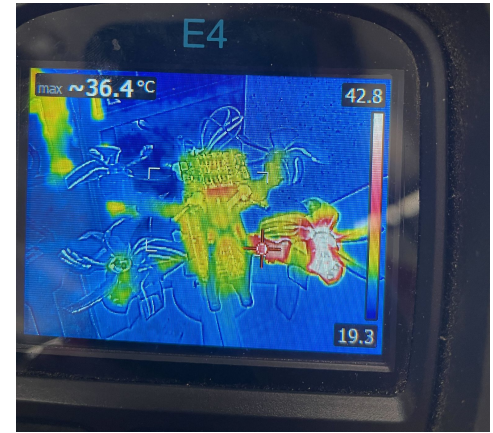
What Was Done

- Researched and procured components for new drone
- Developed new PCBs to interface with PI, ESC, and other breakout boards
- Used Crazyflie to drive PWM and fly while Raspberry Pi was still in development
- Developed and used new test stands to tune P.I.D. controller values



Challenges and Solutions

- Breakout board: Design constraints / signal integrity, materials
 - **Solution:** Increased to 4 layer PCB
- Configuring Pi to run our software:
 - Configuring Pi to run FreeRTOS on one core and Ubuntu on 3 others took significantly more time than was anticipated and ultimately was not accomplished in time
 - **Solution:** Get flying using crazyflie bigquad deck while Raspberry Pi was having trouble
- Faulty Components:
 - Chain reaction of motor failing, ESC failing, another motor breaking, and voltage droop on battery made getting our first flight challenging
 - **Solution:** Replaced components one at a time until a root cause was identified as being the ESC, and added capacitor to battery line



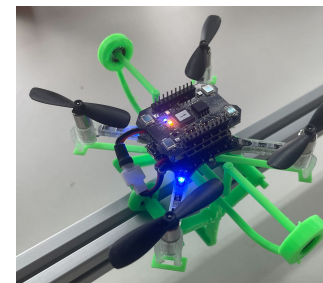
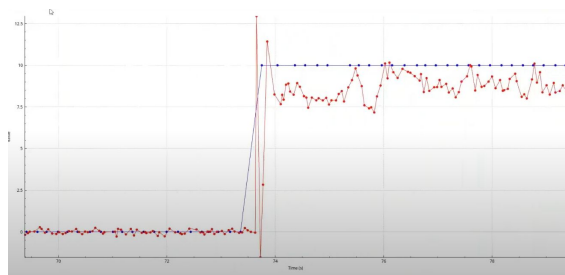
MP-4 Lab Support

Requirements

- CPRE 488 requires MP4 lab to be reworked in order due to:
 - Poor lab instructions
 - Ground station that often crashes

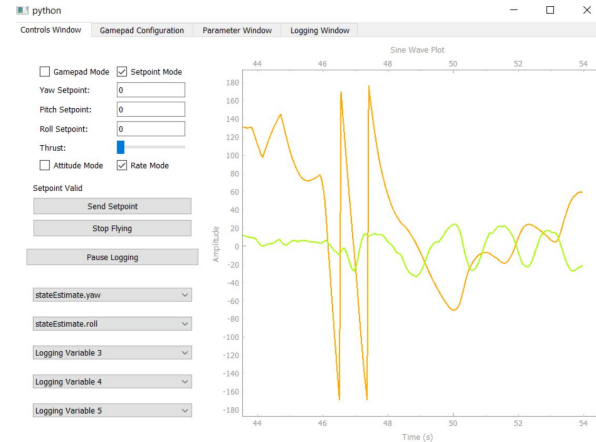
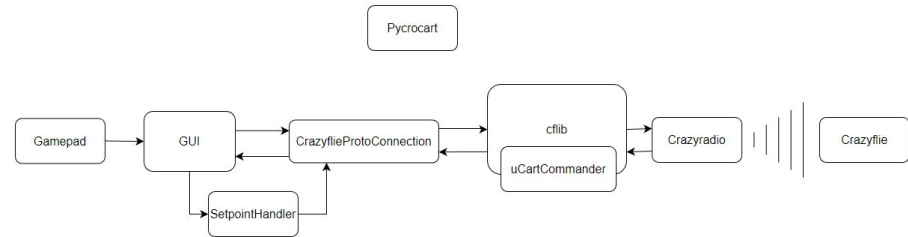
What Was Done

- Reorganized and reworded 40 page lab document to be easier to follow
- Identified bugs within GUI and implemented solution to mitigate them
 - Automatically connect to backend
 - Set parameters from JSON fixed a frequent crashing issue when attempting to set or get parameters
- Developed new XY test stand that can be a base for future positional controller lab component



MP-4: Challenges and Solutions

- Despite efforts to fix bugs in ground station prior to MP4 many random crashes, lag, issues with logging still occurred regularly
 - **Solution:** Developed ground station that was only intended to interface with crazyflies specifically
 - Works significantly better and faster, and is developed in a modular enough way to be easily slotted into existing architecture



YouTube Channel Videos

- Goal was to increase documentation of the microcart code base and to allow future MicroCARTs to be able to pick up where we left off
- Successfully made and uploaded 10 new videos that share knowledge about how confusing parts of system work

Videos We Made

- MP4 Explanation Videos
- Quad Firmware Video
- Test Stand Firmware Video
- GUI Video
- Ground station Architecture Video
- How to run simulation demo
- How to run simple swarm demo
- How to use Lighthouses video
- Microcart Architecture video
- Full year Demo video



MicroCART

@microcart8754 6 subscribers 24 videos

[More about this channel >](#)

Scholars Day Demos

Requirements:

- Develop impressive demos to show to prospective students during scholars day

What was done:

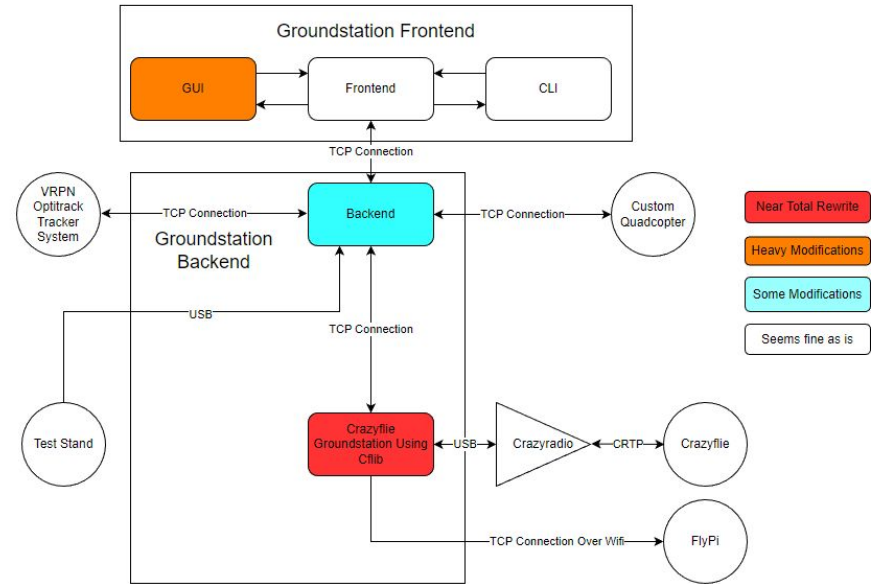
- Developed custom demo utilizing MATLAB simulation of quadcopter dynamics, which compared logged trajectory of quadcopter flown during demo with a simulated version after being flown



- Developed second demo utilizing two drones with uploaded circular trajectories to show a simple swarm

Opportunities for Future Teams

- Ground station rework
- Trim down crazyflie firmware to streamline MP4
- Expand MP4 to include tuning positional controller
- Continue development of FlyPi w/ Raspberry Pi or FPGA of similar form factor



Key Contributions and Total Hours

Team Member	Major Contributions	Total Hrs
Austin Beinder	Debugged custom drone and tuned PID to allow it to fly, created ground station that uses open source drone interfacing software, created simulation demo to show to prospective students, helped with cpre 488 lab, made several walkthrough videos	277
Cole Hunt	Helped with drone communication protocols and testing communication pipelines. Worked on firmware development for multicore system. Integrated firmware tests into Ubuntu/Bare-Metal Environment.	131
Connor Ryan	Revised the PCB design for size constraints, undervoltage protection, and included connections for expansion decks. Added a serial control interface to the teststand.	197
Emily Anderson	Worked on making GUI improvements and user testing for 488 lab and made GUI walkthrough video for future MicroCART members	128
Grant Giansanti	Integrated and tested hardware ESC for new drone, developed and implemented new .json file for MP4, and wrote low level baremetal code for Seeeduino and Raspberry Pi	163
Tyler Johnson	Developed new test stand for drone, edited MP4 doc, tested and developed PID values on flypi	155
Gautham Ajith	Edited Youtube video, tested GUI errors and investigating features, helped set up demo for Scholars Fair, helped on creating TCP connections between pi and computer, decoded and send CRTP packets using CFlib across network, and worked on integrating multicore processing into raspberry pi	144

Conclusion

Successes

- Successfully demonstrated new flying quadcopter/ test stand system
- Successfully updated MP4 lab document, adding support materials, and new ground station functionality
- Successfully demonstrated system to prospective students
- Learned a ton

Struggles

- Unable to get Raspberry Pi 2W to act as flight controller
- Issues with deployment of MP4
- Team Communication

