Agricultural Drone Refilling System

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Objective

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The Problem

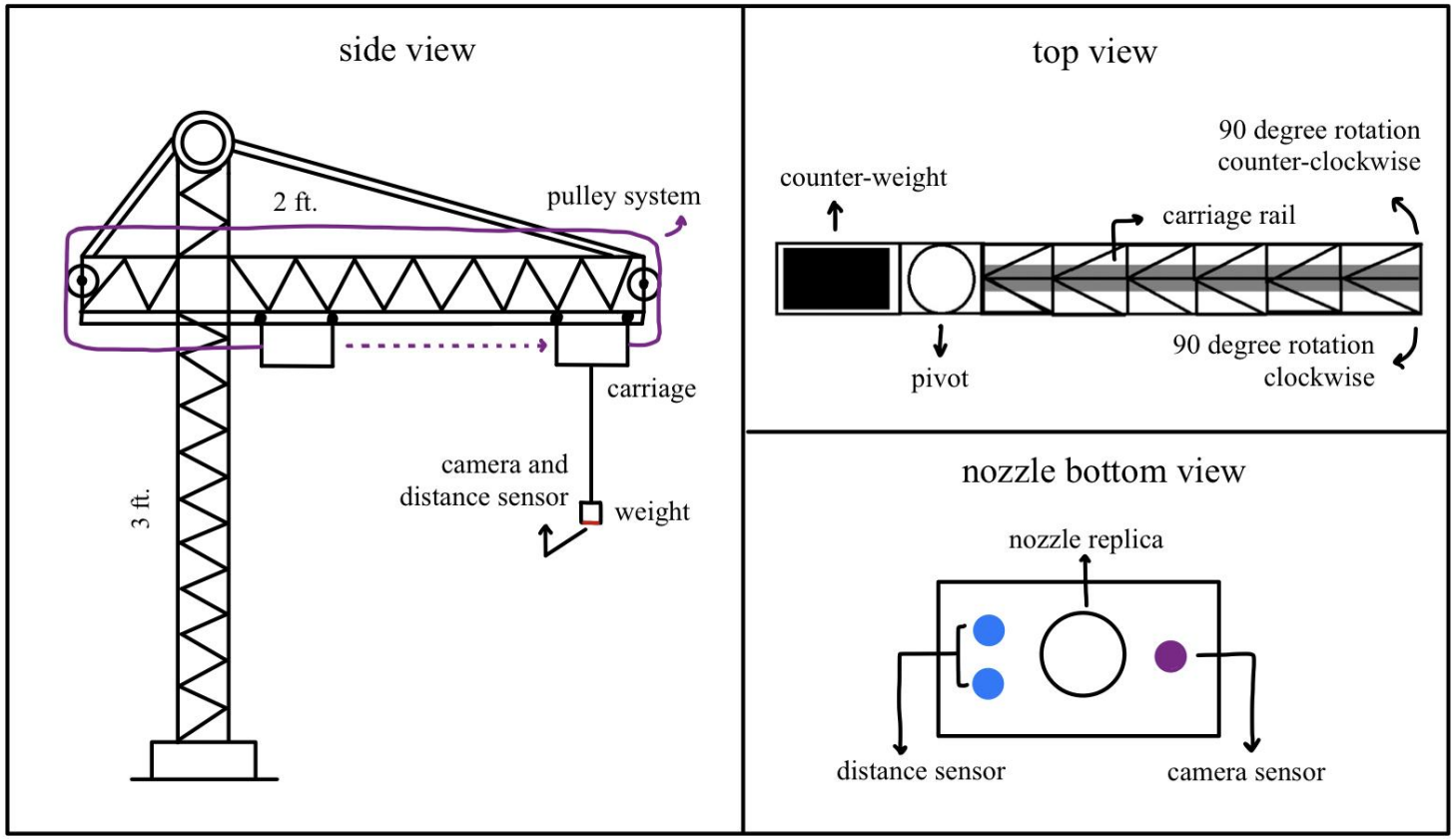
- Agricultural drones, specifically for spraying (fertilizer, pesticide, seeds, etc.), are refilled manually
- Tedious process for large fleet of drones

Our Solution

- Automate drone refilling system
- Increase farm productivity
- Optimize drone fleet's downtime

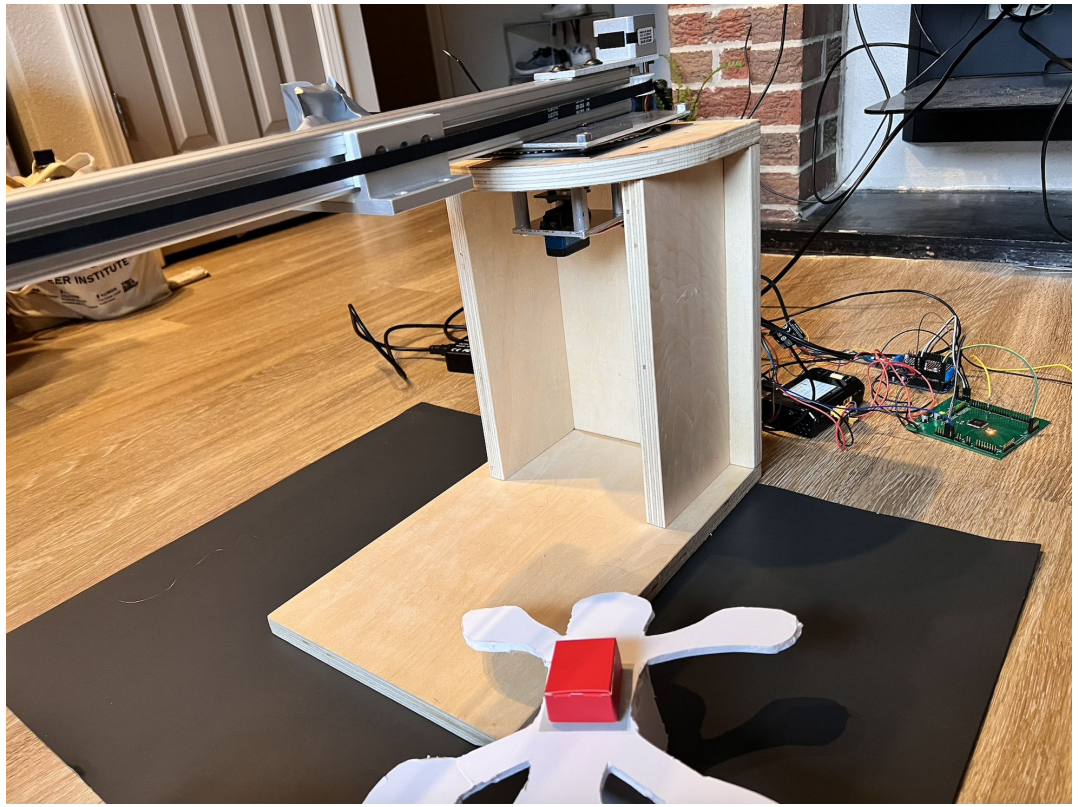
Design

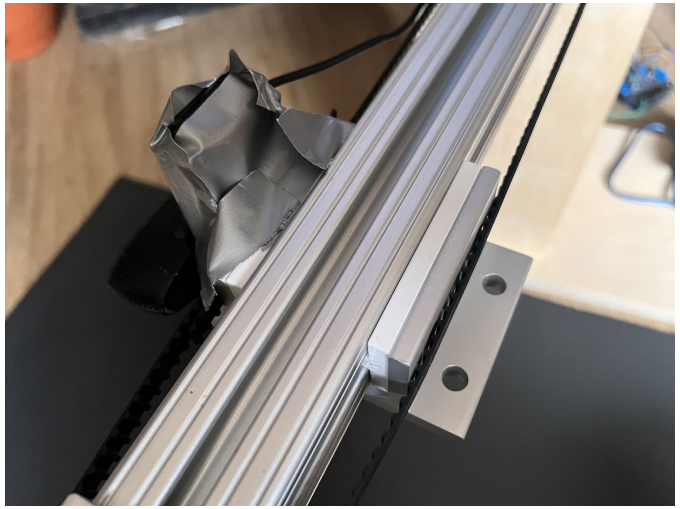
Original Mechanical Design



Final Mechanical Design

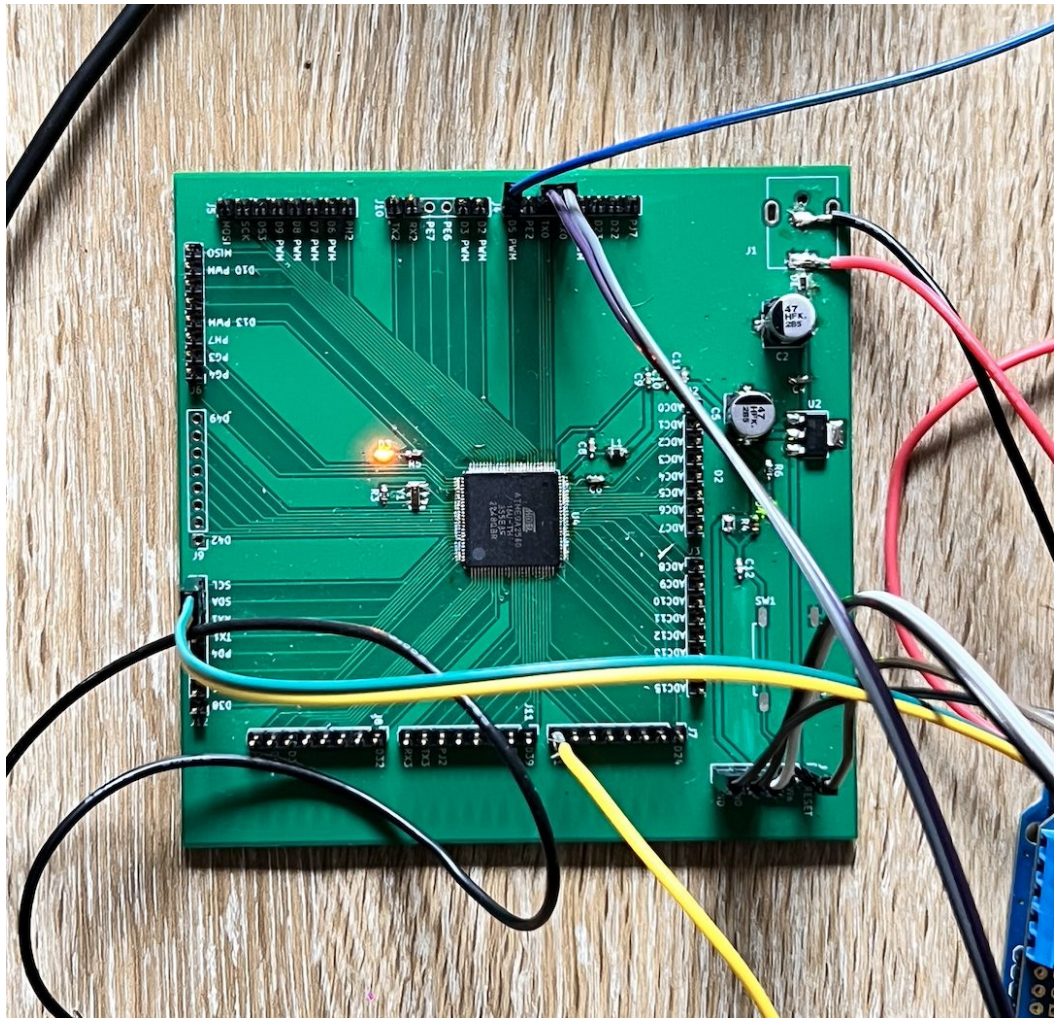
- Downsizing the entire system





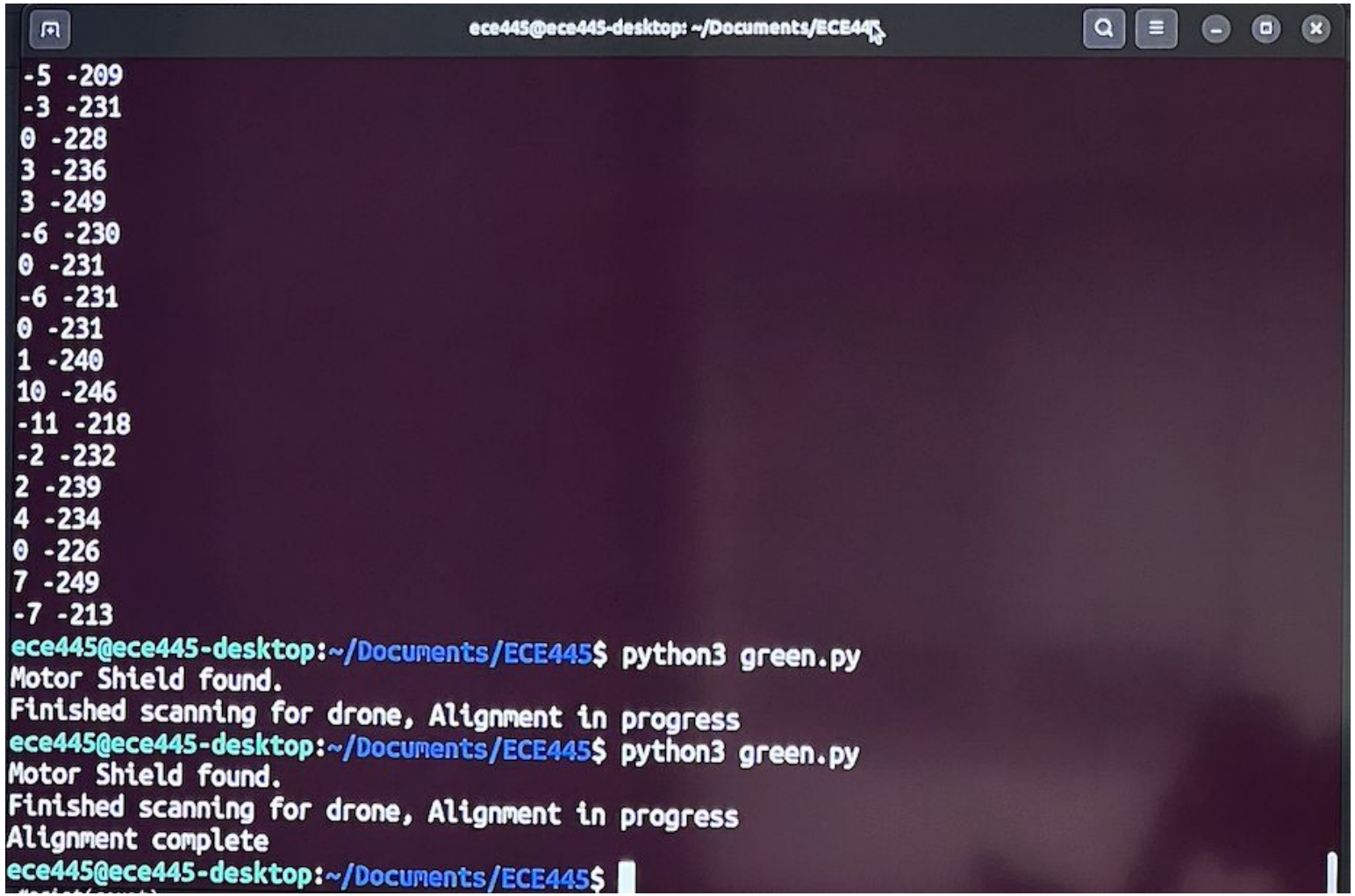
PCB Design

- ATmega 2560
  - Numerous I/O pins



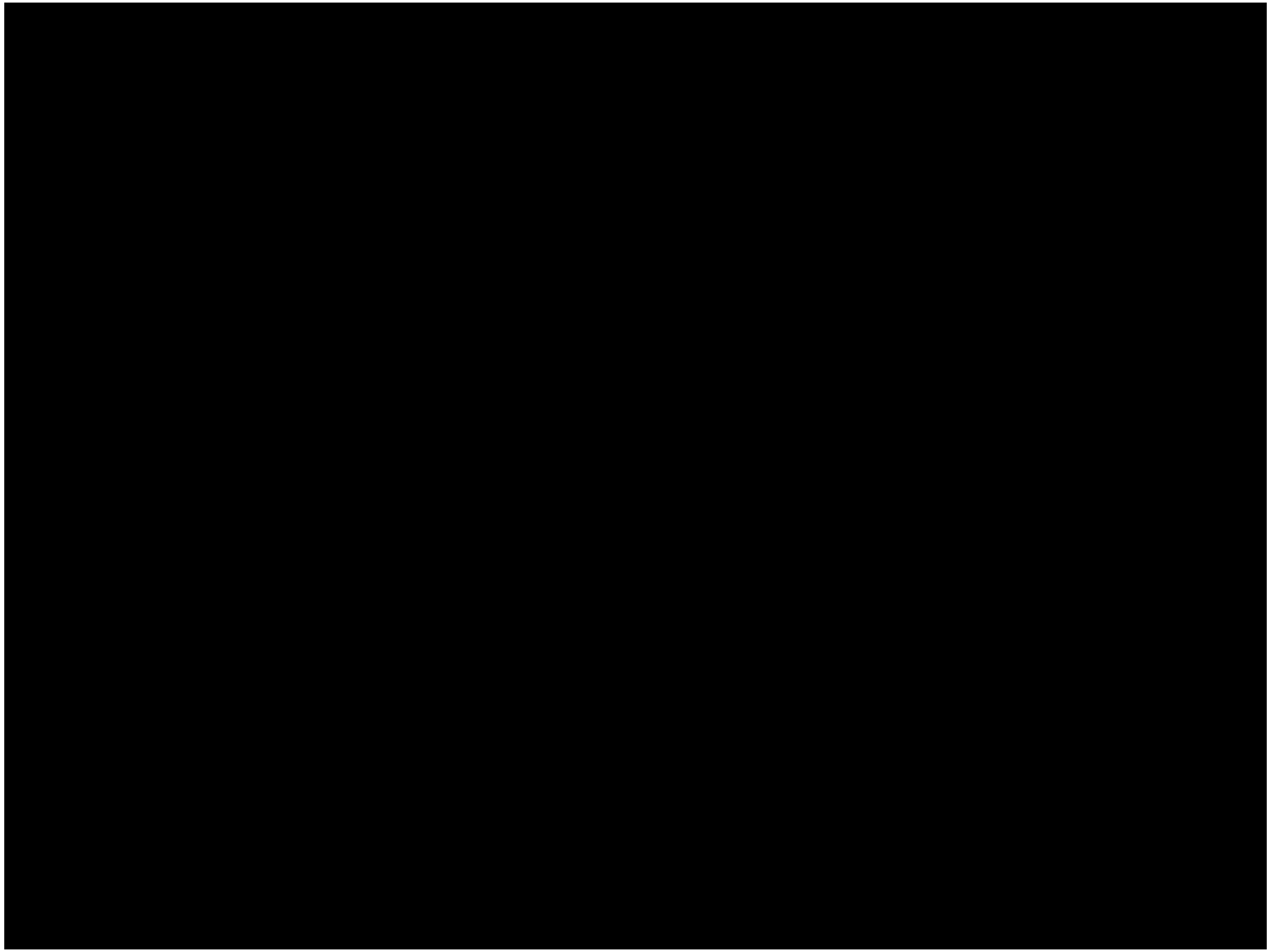
Software Design

- OpenCV
- Search algorithm



Video

Video



High Level Subsystems

High Level Subsystems

Refilling System

Crane Subsystem

- Uses stepper motors to move the dispensing system in a controlled and precise manner

Alignment Subsystem

- Uses Raspberry Pi for image processing and a camera for accurately aligning to the drone's fill port

Control Subsystem

- Controls crane movement and monitors the dispensing process with particular notifications

Power System

- Provides necessary power to the entire system

Drone Replica

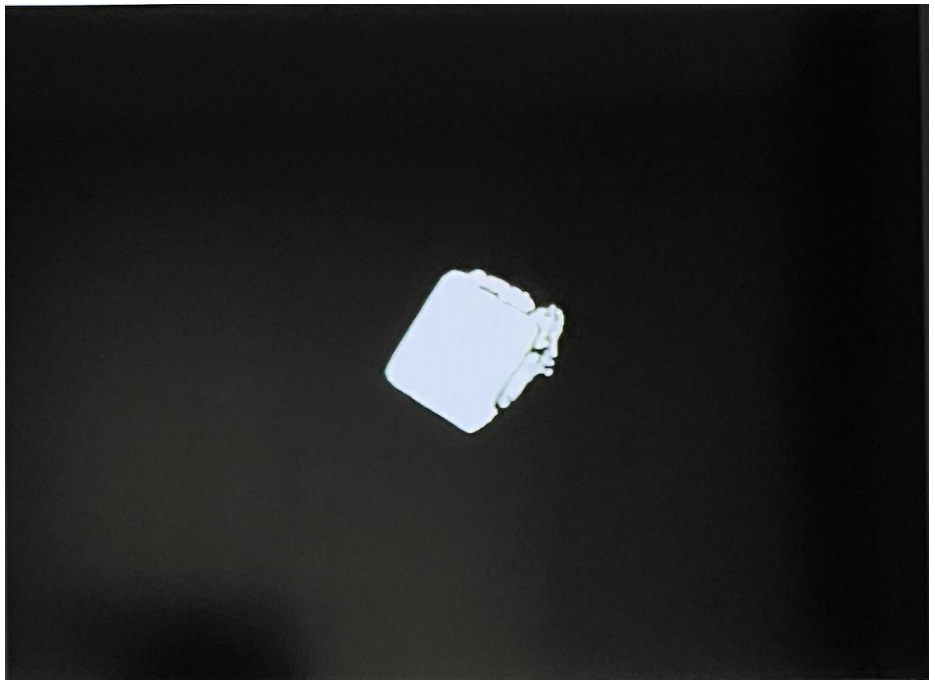
- Represents a high level replica of the important parts of the drone

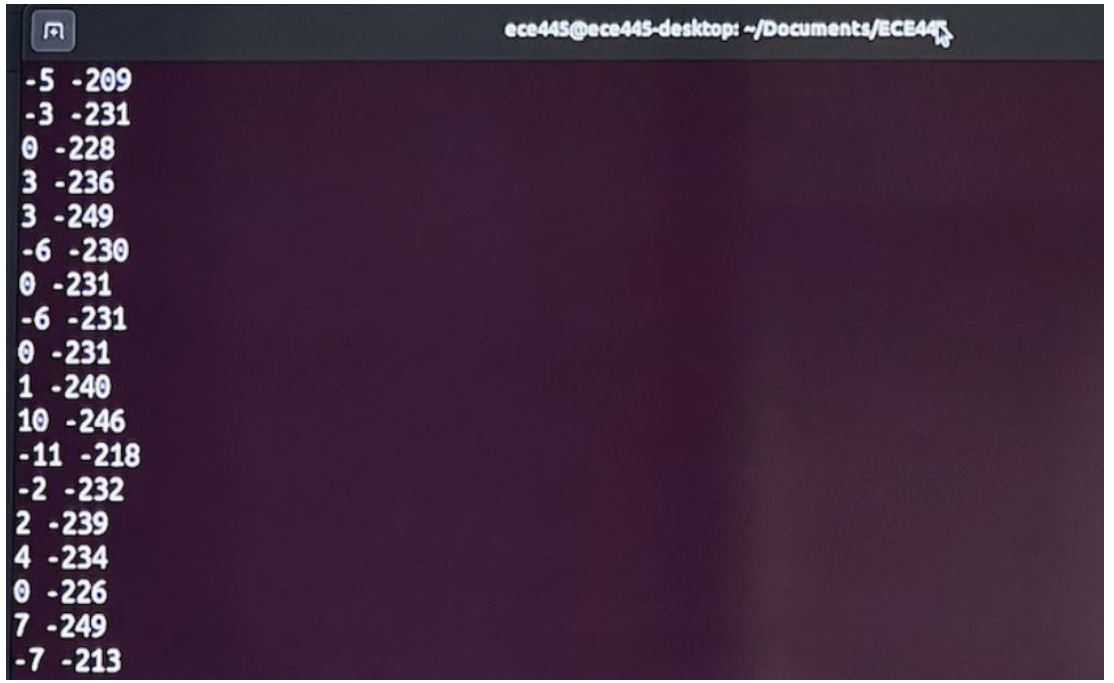
Requirements and Verifications

Alignment Subsystem

Requirements	Verification	Verified?
Locate fill port of a drone located in the working area	The system notification should switch from displaying searching notification to the aligning notification	Yes
Align replica nozzle to the refill port on the drone	Before the replica nozzle is lowered, the replica nozzle should be above the refilling port	Yes
Do not crash the replica nozzle into the drone	The replica nozzle is properly lowered into the refilling port and not dropped anywhere else	N/A

Alignment Subsystem





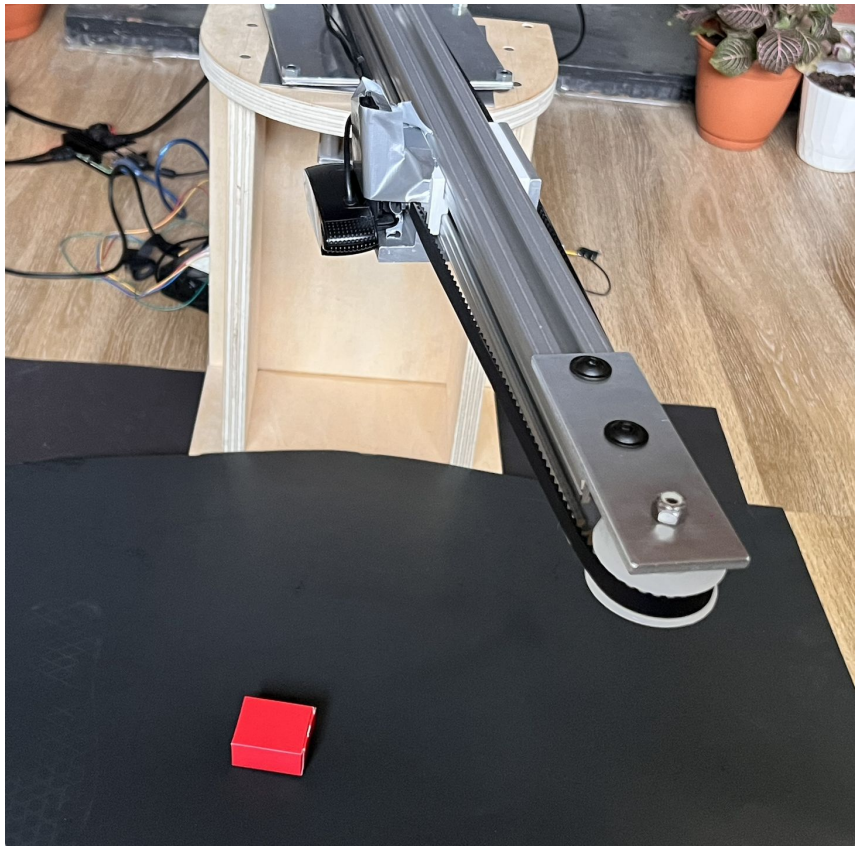
Crane Subsystem

Requirements	Verification	Verified?
Move the dispensing system to the correct location reliably	The crane's movement axes should move in a smooth fashion without getting caught or snagged	75% of time
Support the weight of the dispensing subsystem	The crane does not break and remains structurally sound	Yes

Control Subsystem

Requirements	Verification	Verified?
Displays system notifications based on current action	The appropriate system notification is displayed for the current operating mode	Yes
Operates the crane in a controlled manner without overshooting end stops	1. The carriage on the crane arm does not fall off the front or back ends 2. The crane does not rotate beyond the designated 180 degree range of operation and cause damage to itself	Yes
Communicates with alignment subsystem to align replica nozzle to the refilling port	The crane's axes move appropriately based on the output from the alignment subsystem	Yes

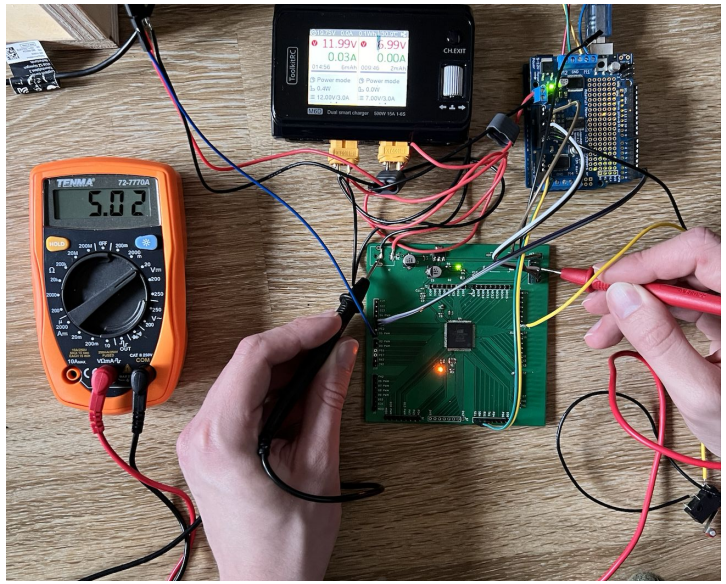
Control Subsystem

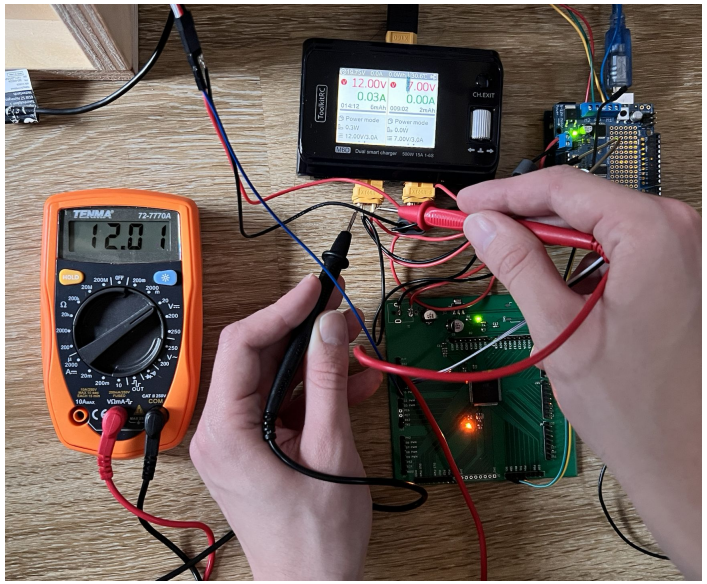


```
ece445@ece445-desktop:~/Documents/ECE445$ python3 green.py
Motor Shield found.
Finished scanning for drone, Alignment in progress
ece445@ece445-desktop:~/Documents/ECE445$ python3 green.py
Motor Shield found.
Finished scanning for drone, Alignment in progress
Alignment complete
ece445@ece445-desktop:~/Documents/ECE445$
```

Power Subsystem

Requirements	Verification	Verified?
Power supply provides the necessary 5V and 12V with a ±15% margin of error	A digital multimeter will be used to measure the 5V and 12V lines to ensure that the appropriate voltages are being supplied	Yes





Successes and Challenges

Successes

Alignment Subsystem

- Image processing
- Locating the fill port and stopping when necessary

Crane Subsystem

- Smooth travel and drive of carriage
- Precise control of crane arm

Control Subsystem

- Serial communication between Alignment Subsystem
- Controlled motors reliably
- Communication between distance sensor and display

Power Subsystem

- Maintained the proper amount of power for the entire system

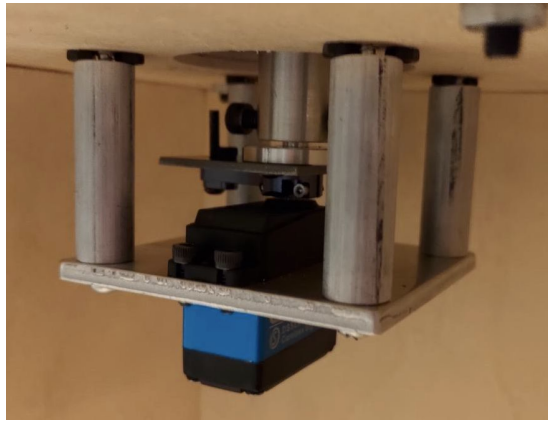
Challenges

Alignment Subsystem

- Filtering noise from camera frame
- Limited control of camera settings
- Reliability
- LEDs too bright

Crane Subsystem

- DC motor issues
  - Rotary encoder
  - Limited torque
- Servo horn stripped
  - Designing new adapter plate



Control Subsystem

- Serial communication with Raspberry Pi
- Non-blocking wait

Power Subsystem

- Voltage spike when testing arm control servo

Conclusions

Experience and Future Development

Conclusions

- Start testing as early as possible
- Making sure all parts work properly beforehand
- Work on integrating subsystems earlier

Improvements

- Continuous running mode
- Automatic detection of drone arrival/drone notifying station on arrival

Advancements to our Project

- Working with a third axis
- Accounting for wind
- Adding solar panels to power entire system
- Real-time tracking

Thank you!
Questions?

The Grainger College of Engineering

UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN