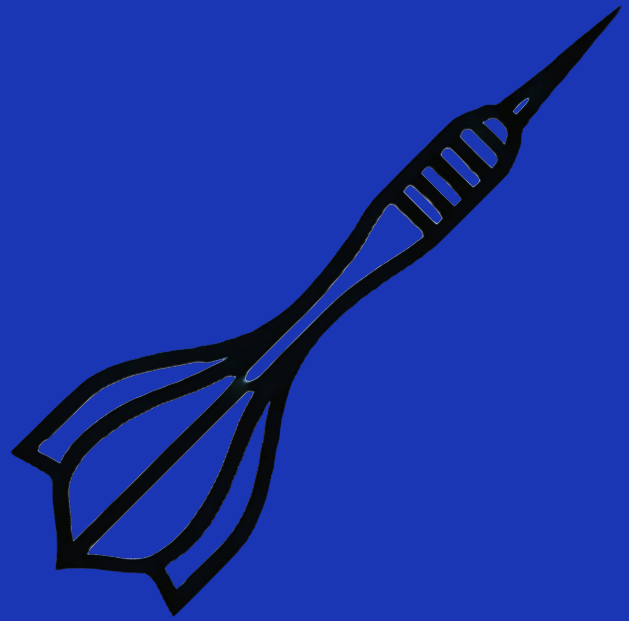
GROUP 27

D.A.R.T

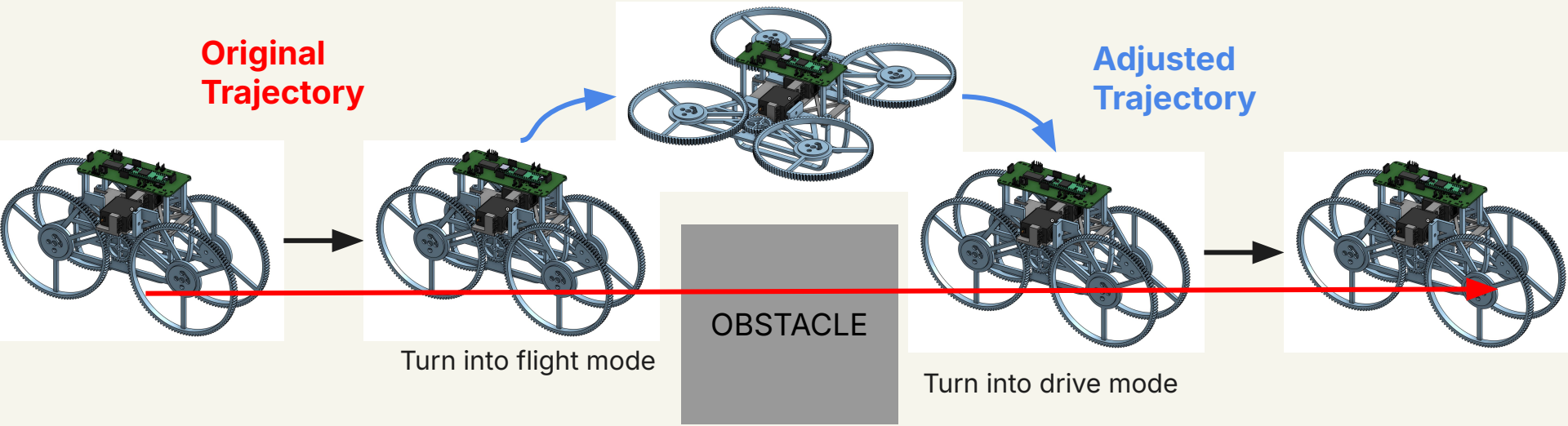
Driving Aerial Robot Technology



Nikhil Ograin, Smit Malde, Amal Malde, Andrew Ji, Mary Bokuchava

Initial Proposal

Our project aims to develop a **transformable robotic vehicle** that can transform from a car to a drone. It will be equipped with **ultrasonic sensors** to detect obstacles in its path, and navigate around them, either by **maneuvering on the ground or flying** over it.



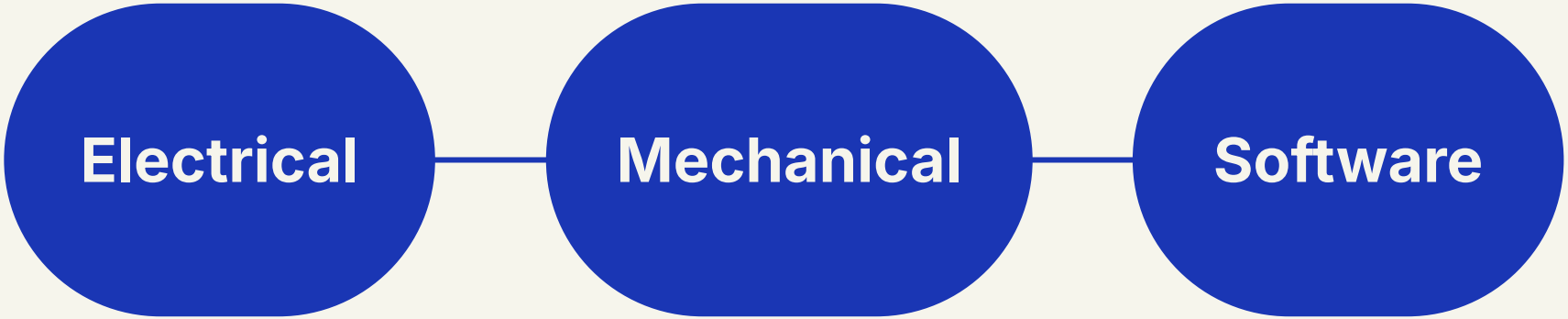
Initial Goals

Successful Transformation: Develop a mechanism that allows the vehicle to reliably transform between car and drone configurations.

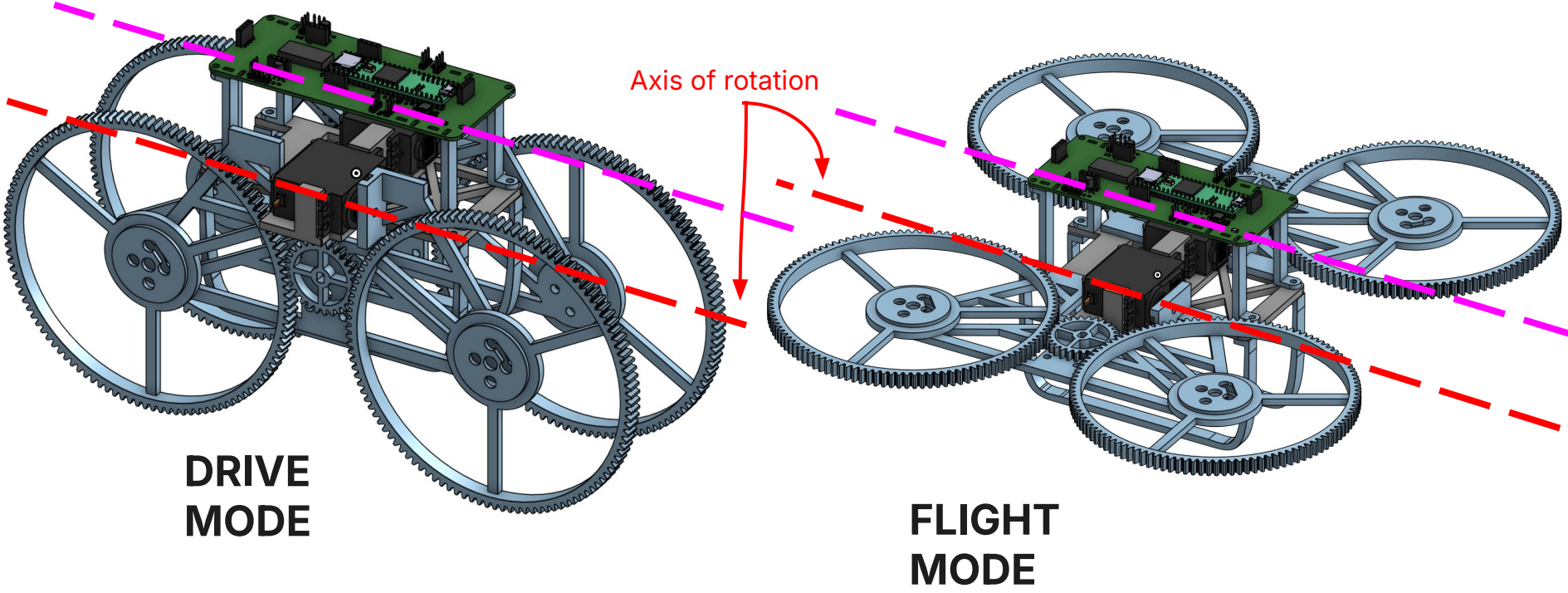
Obstacle Detection and Avoidance: Implement an effective (6DOF) obstacle detection system using ultrasonic sensors to enable the vehicle to navigate around obstacles both on the ground and in the air through sensing and planning.

Optimization: utilize weight-saving methods and implement power optimization to ensure the robot is as efficient as possible to maximize operation time.

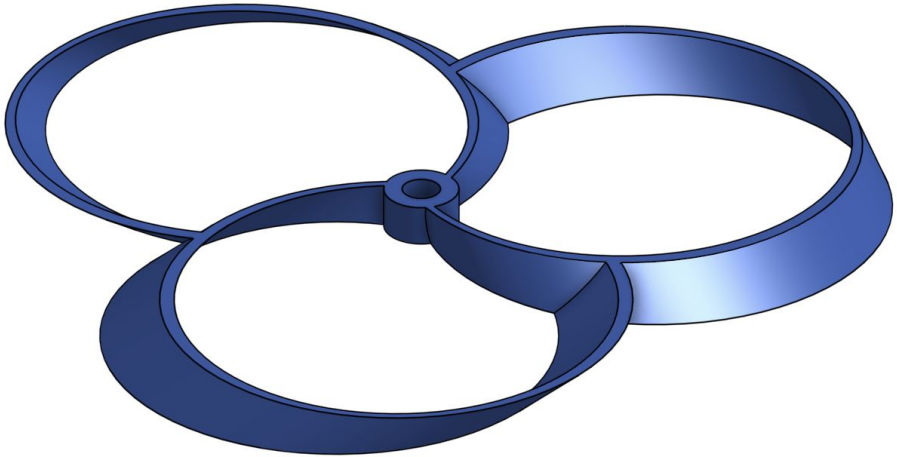
System Design



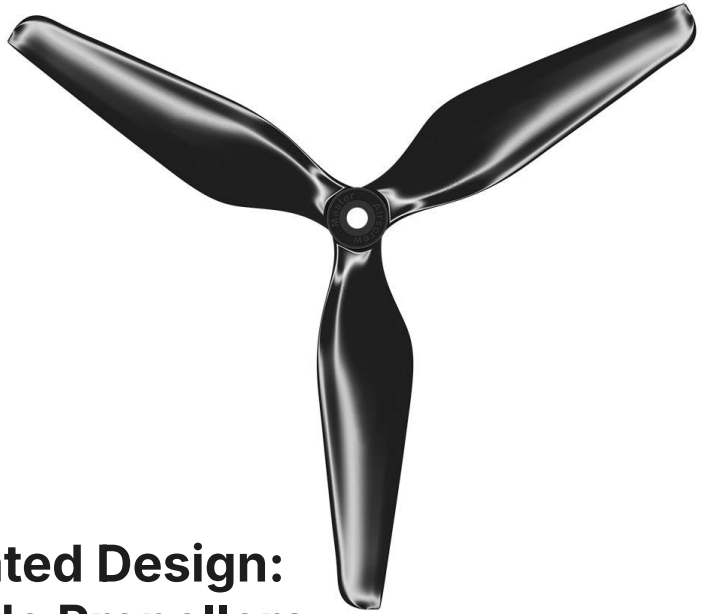
Mechanical - Body



Mechanical - Propellers



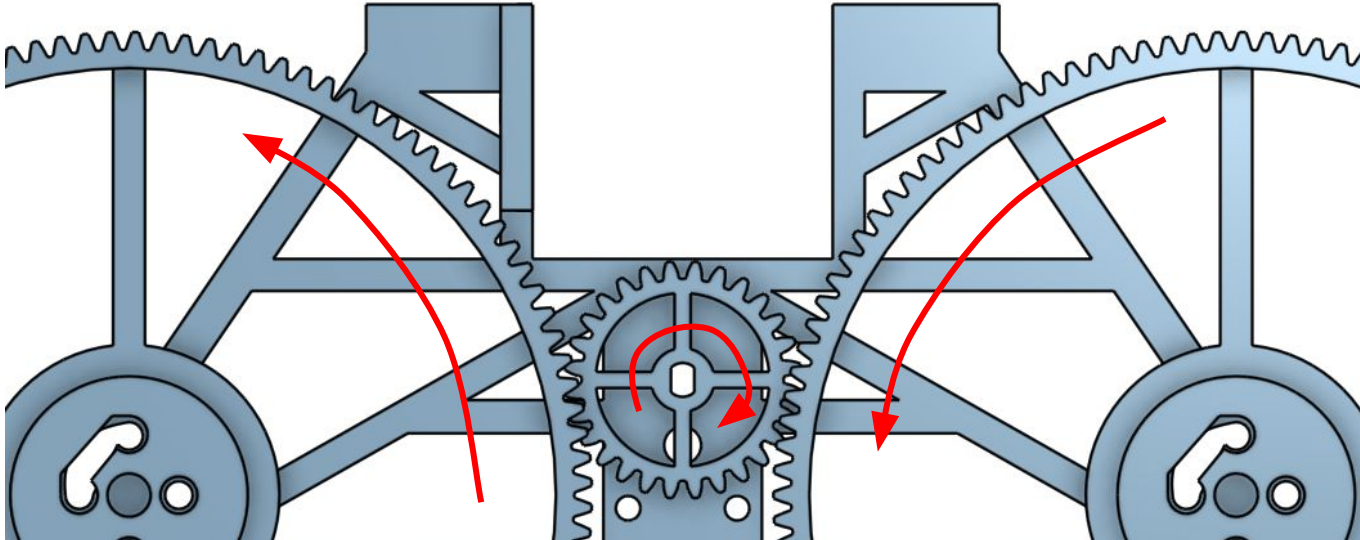
Original Design:
Toroidal Propellers



Updated Design:
3-Blade Propellers

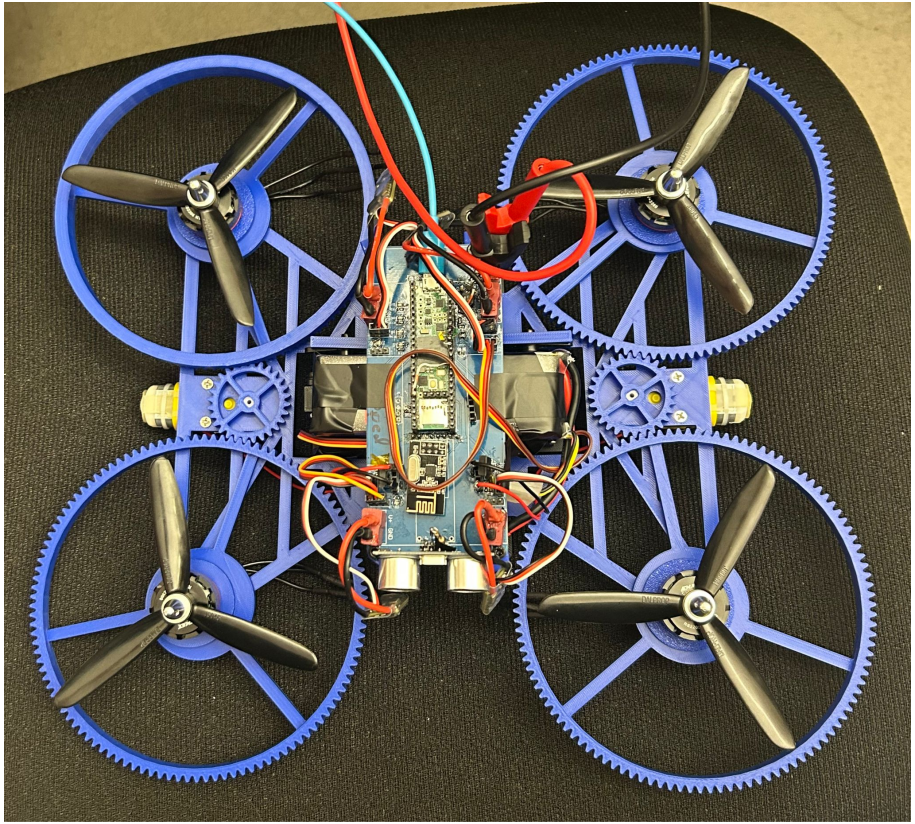
Mechanical - Driving

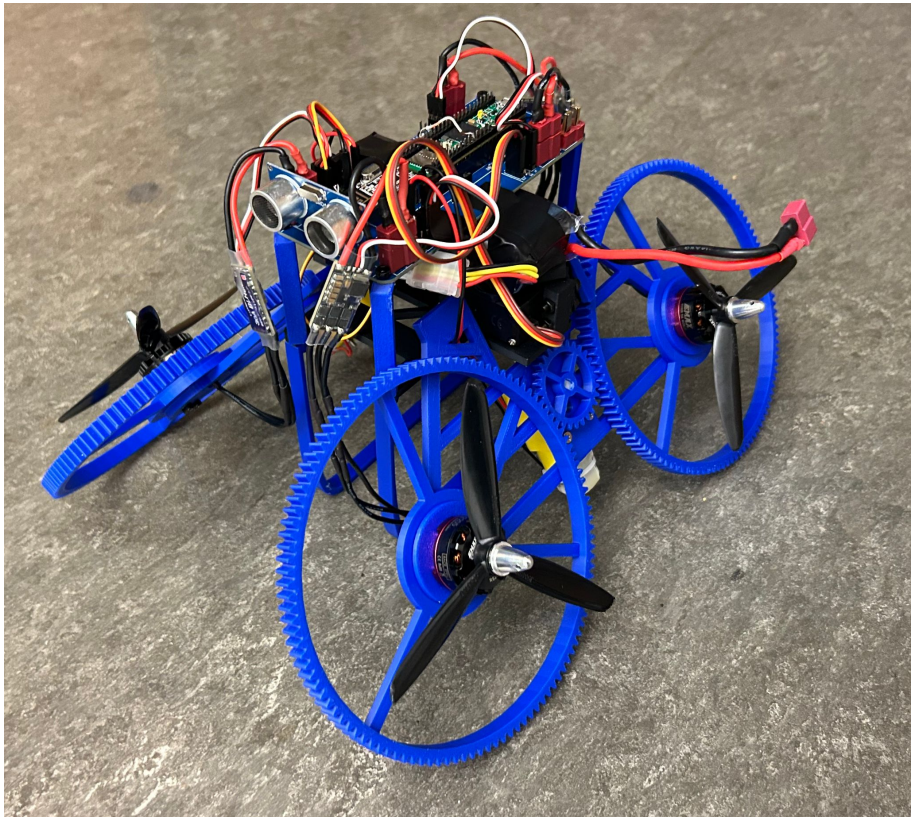
DC Motor Standard: 3 ~ 7.2VDC
200 RPM (1 : 48) Shaft Motor
(28 : 115) ~ (1 : 4.1) Shaft to wheel gear ratio



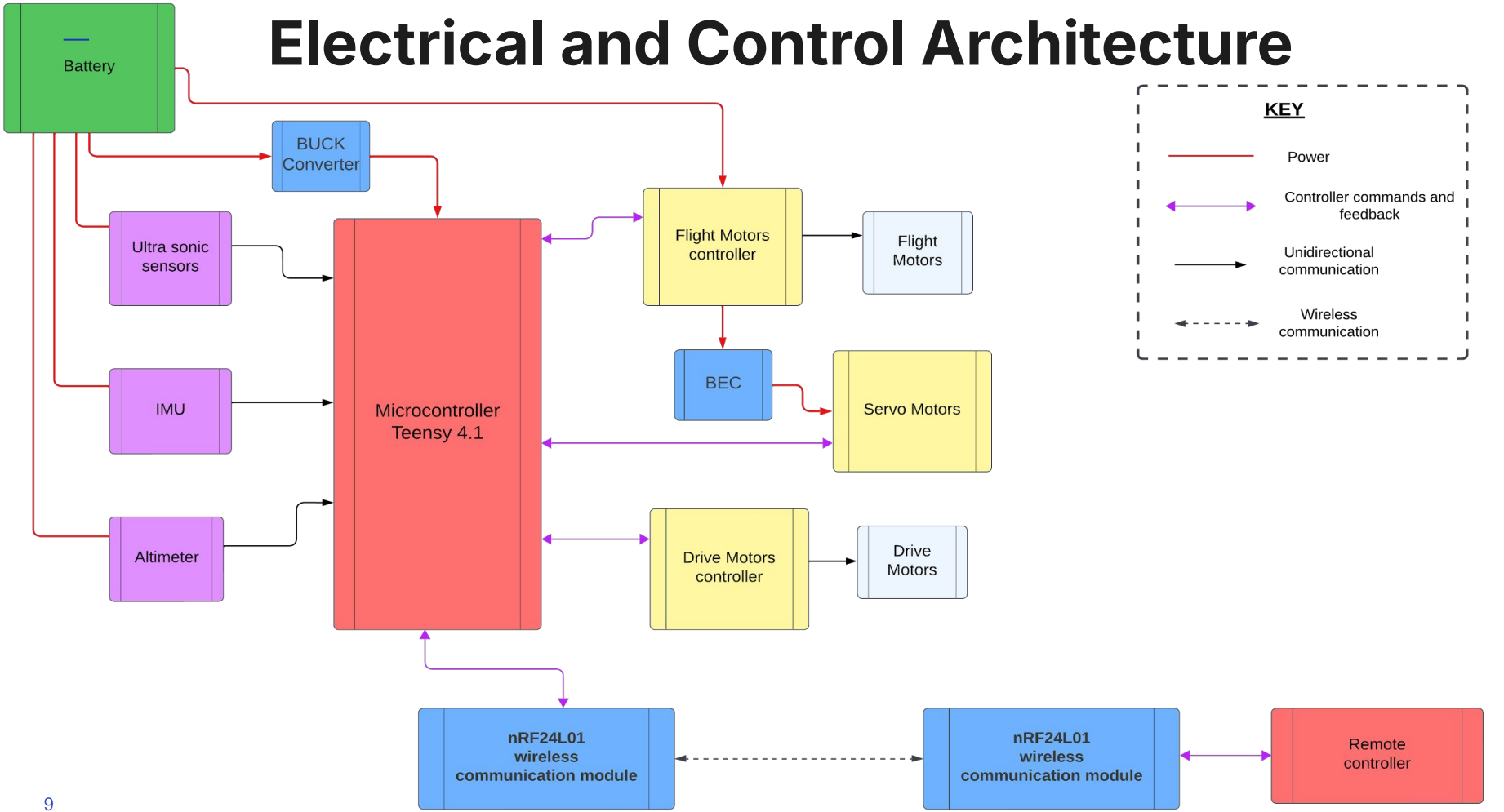
Mechanical - Results

- Moment of Inertia
- Weight Distribution
- Stability



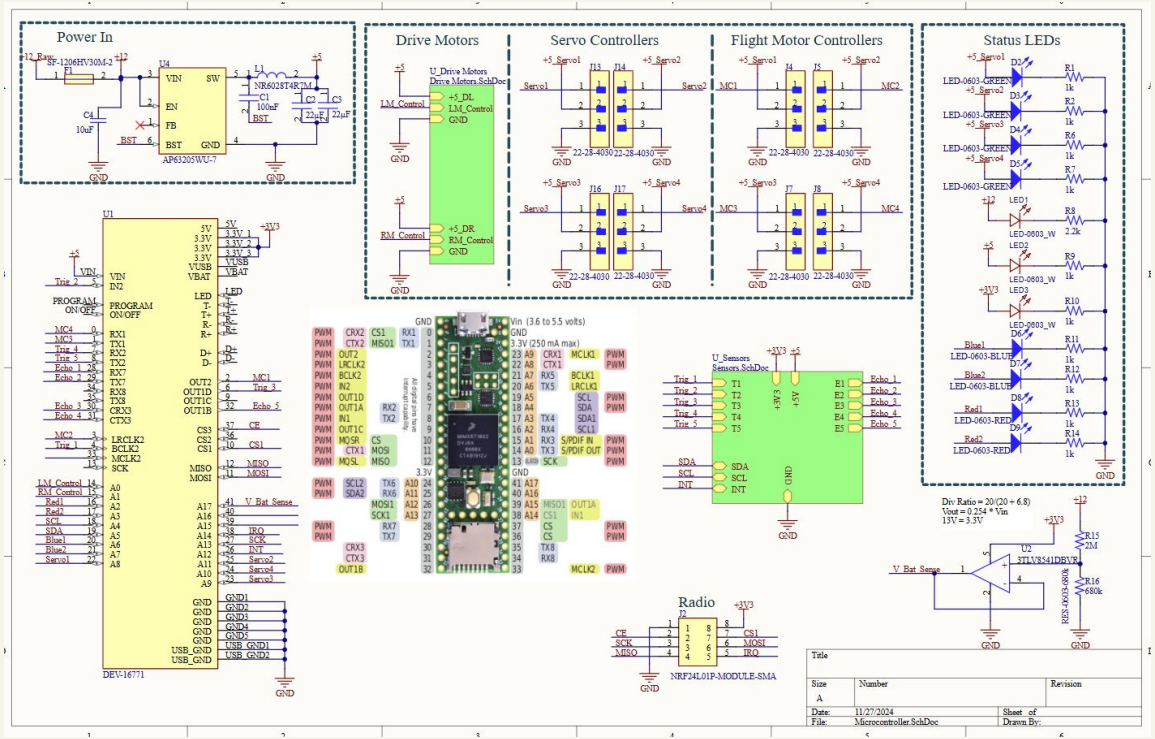


Electrical and Control Architecture

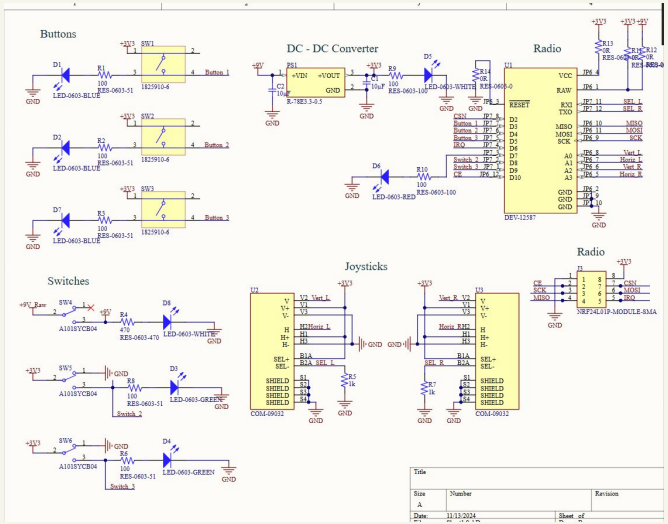


9

Electrical Schematics



Drone Body



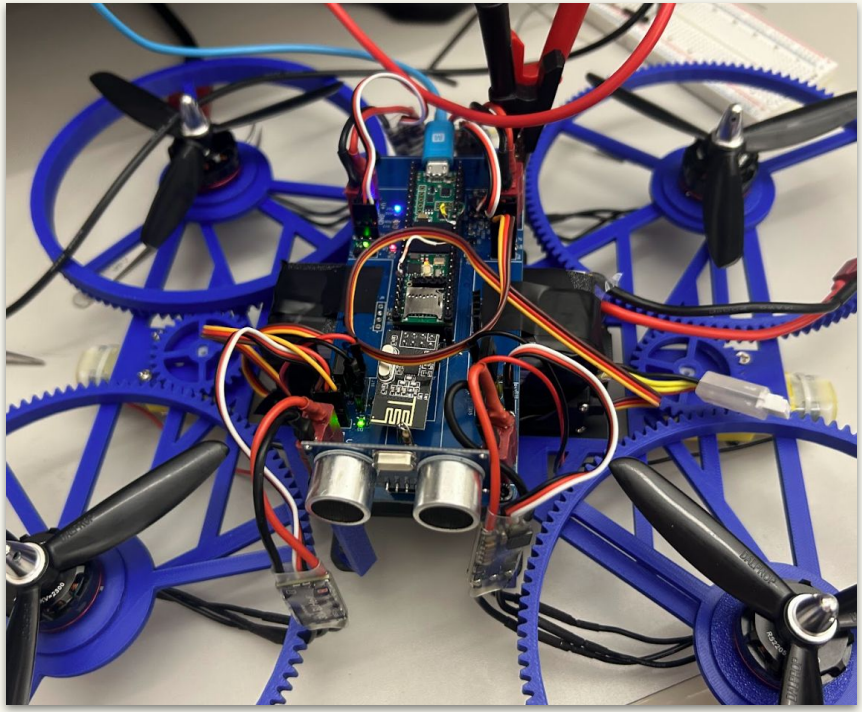
Remote Controller

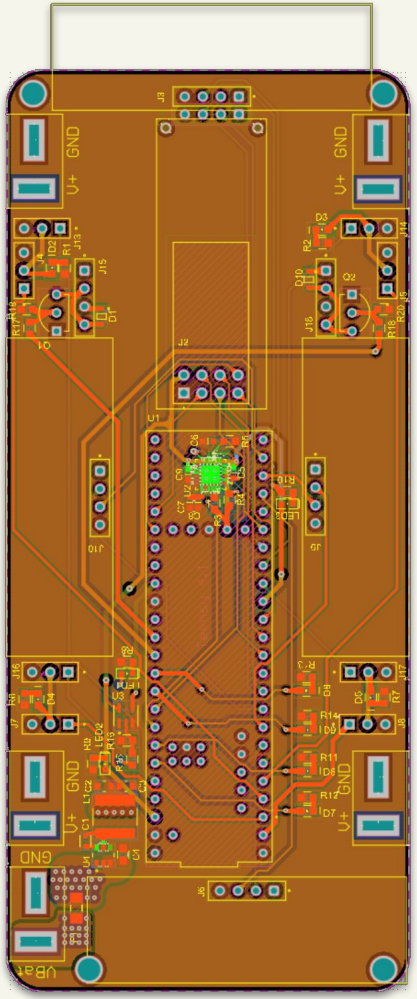
Electrical - Body

Carrier board to hold flight controller, receivers and sensors
Power Voltage = 12V
Power distribution to:

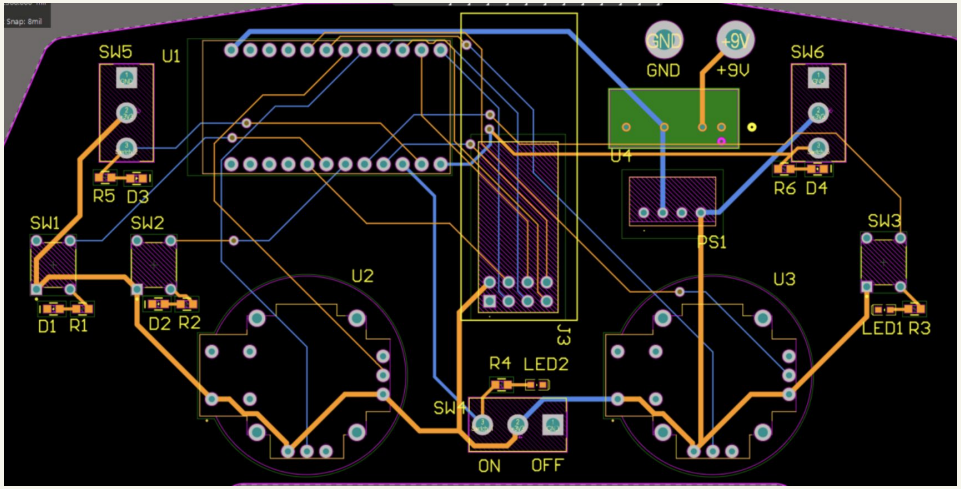
- 4x flight motors
- 4x ESCs
- 2x drive motors
- 5x Ultrasonics
- 2x Servos
- Teensy 4.1
- IMU MPU6050
- Radio nRF24L01

30A Capable





Electrical - Remote



Power Voltage = 9V

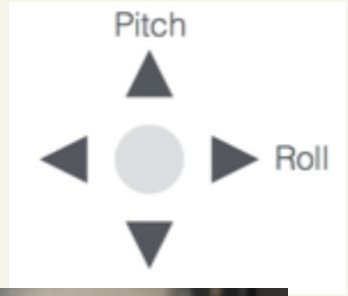
Power distribution to:

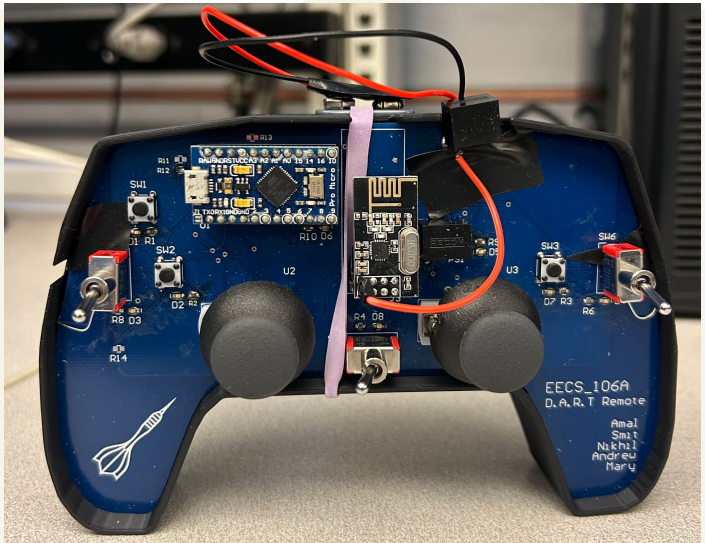
- Radio nRF24L01
- Arduino pro micro
- Joysticks for flight control and drive control
- Modes switches and E-stop controls.

Flight Controls:

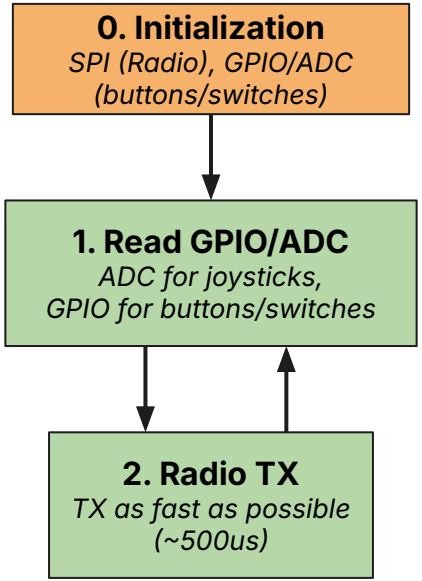
Left Joystick:

Right Joystick:

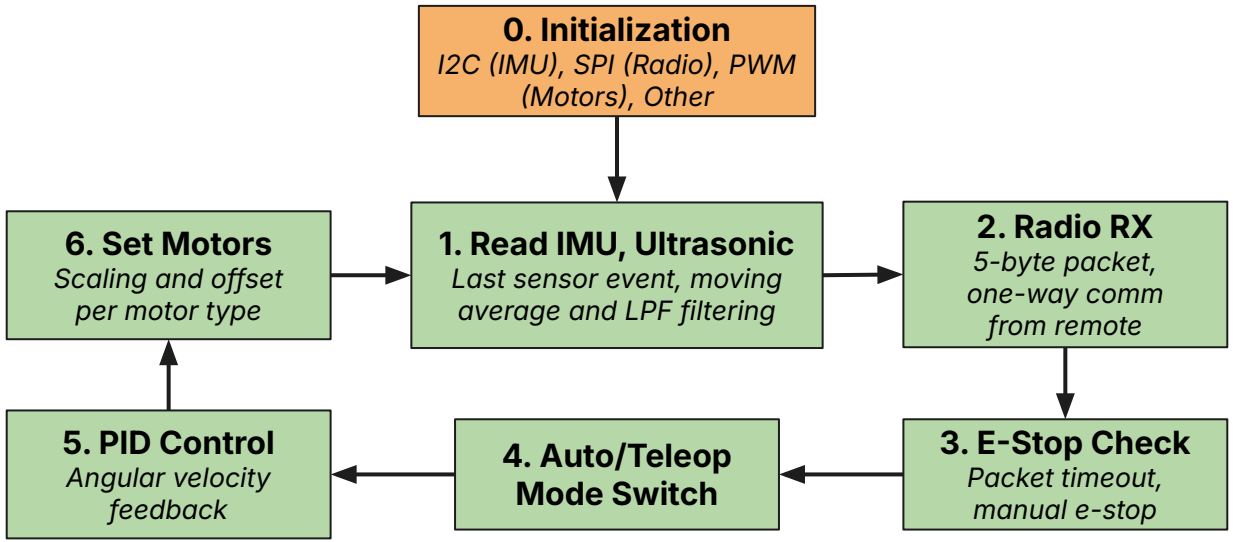




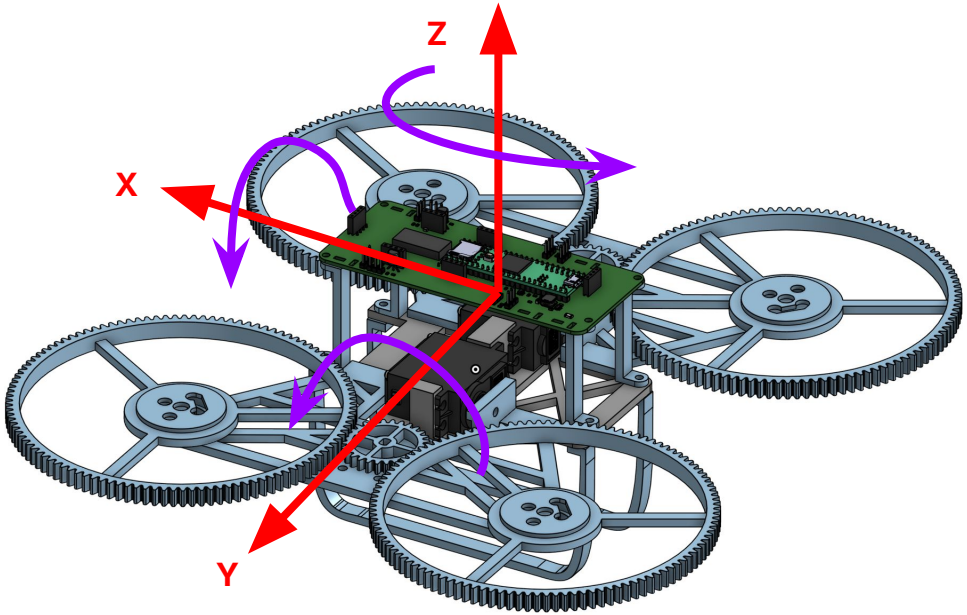
Software - Remote Superloop



Software - Vehicle Superloop



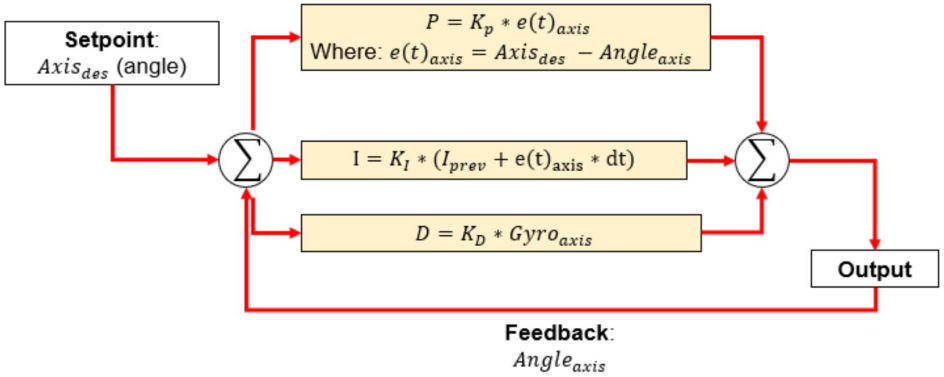
Software - Flight Feedback

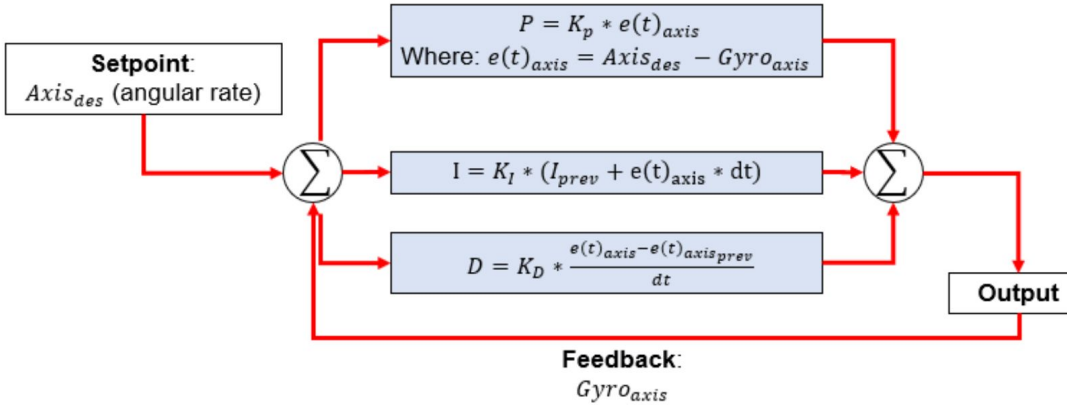


IMU

- MPU6050
- 6DOF
- I2C communication
- (+) Widely supported
- (-) Significant noise

Software - PID Control



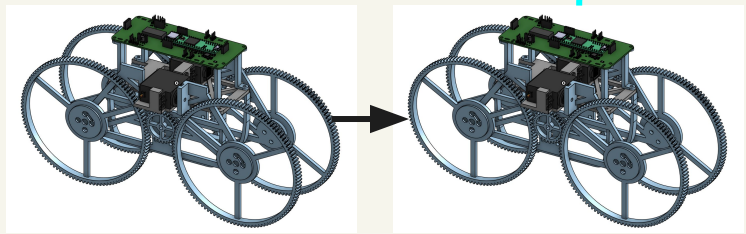


Final System Design

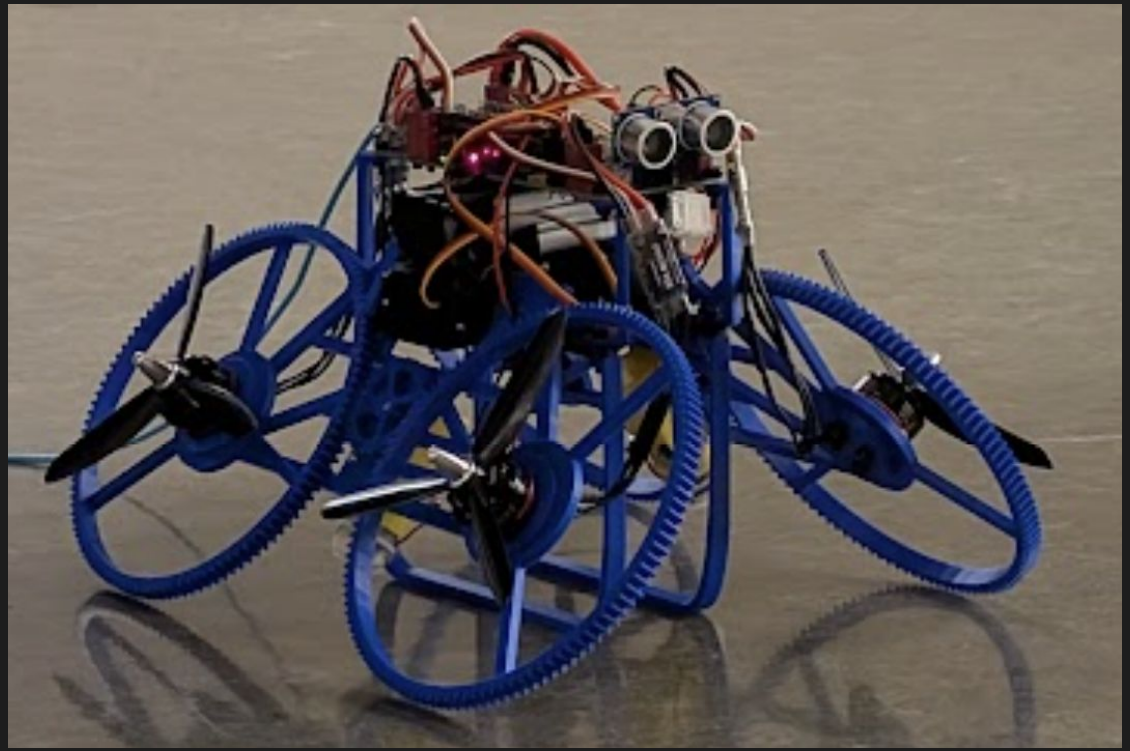
Sensing: Ultrasonic sensors detect obstacles

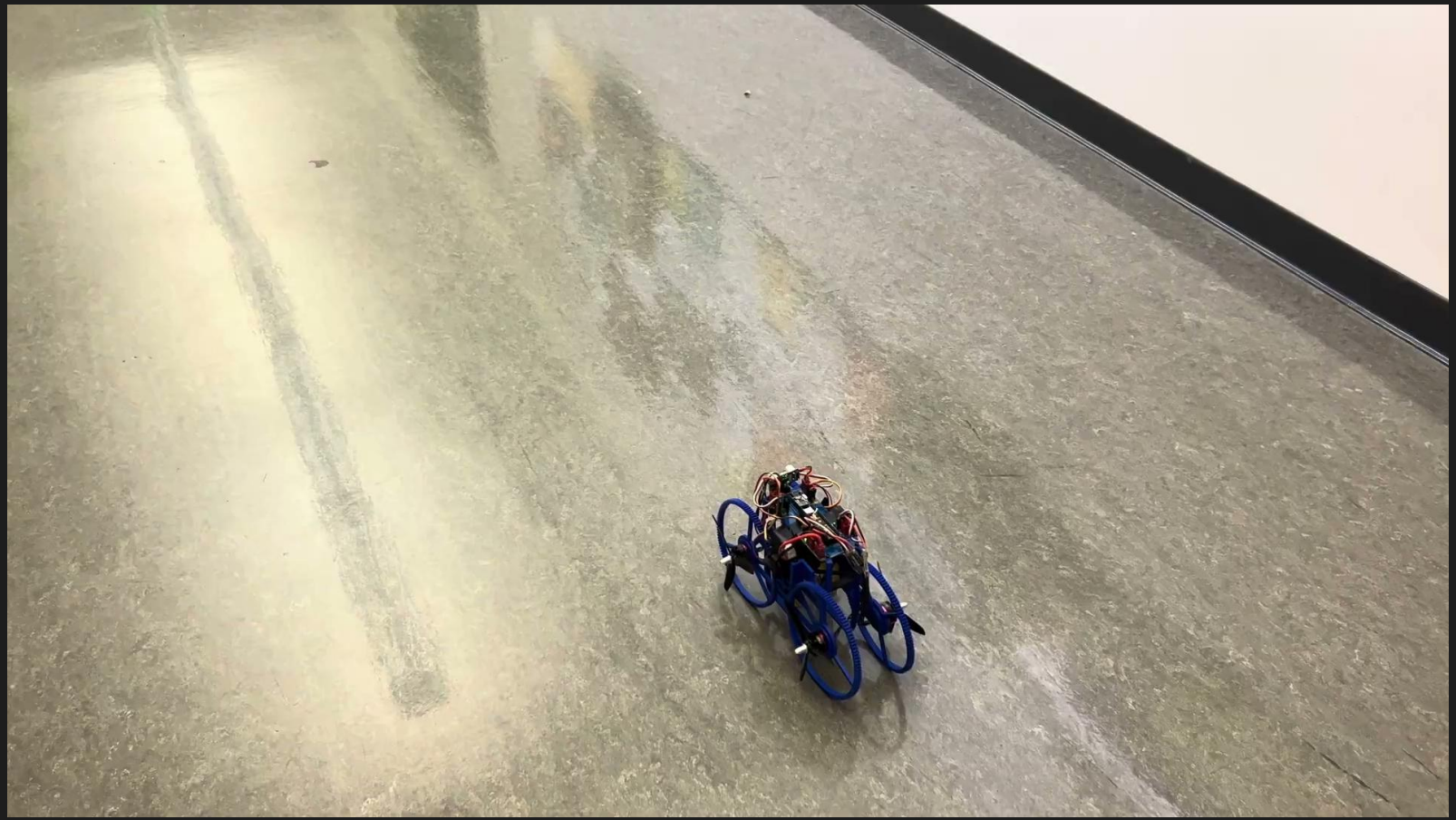
Planning: Robot readjust original path to overcome obstacles using flight mode

Actuation: Activates flight mode once obstacle distance < threshold distance. Begins flight until it overcomes the obstacle and returns back into drive mode.



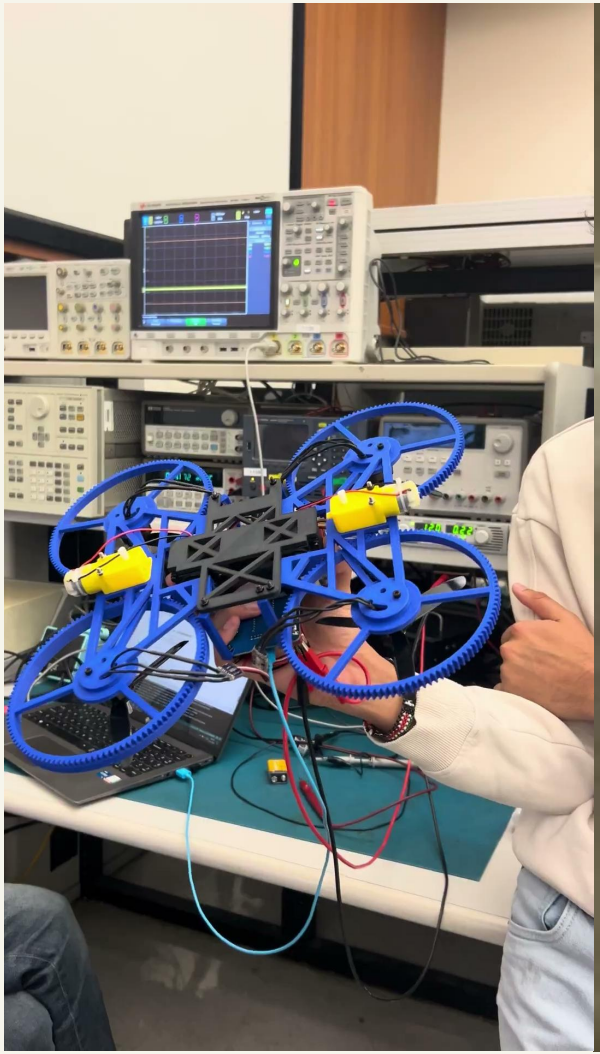
Demo





Limitations

- Budget Limitations
  - Had to custom design flight controllers
  - IMU
- Ultrasonic has inconsistent reading based off of the reflected material
- Material Limitations
  - Using 3D print instead of carbon fiber
- Latency in control systems
  - Processing data from radio and IMU
- FPU operations slow on embedded system MCUs
- Lack of experience with UAVs
- Number of appendages



Future Work and Applications

- Stabilize and improve flight control
  - Filtering IMU data
  - Improving tuning of PID
- Extend support for more accurate sensing technologies such as infra-red or LiDAR
- Improving structural soundness
  - reducing flex during flight
- Improving our path planning
- Integrate Simultaneous localization and mapping (SLAM)
- Use Terrain recognition

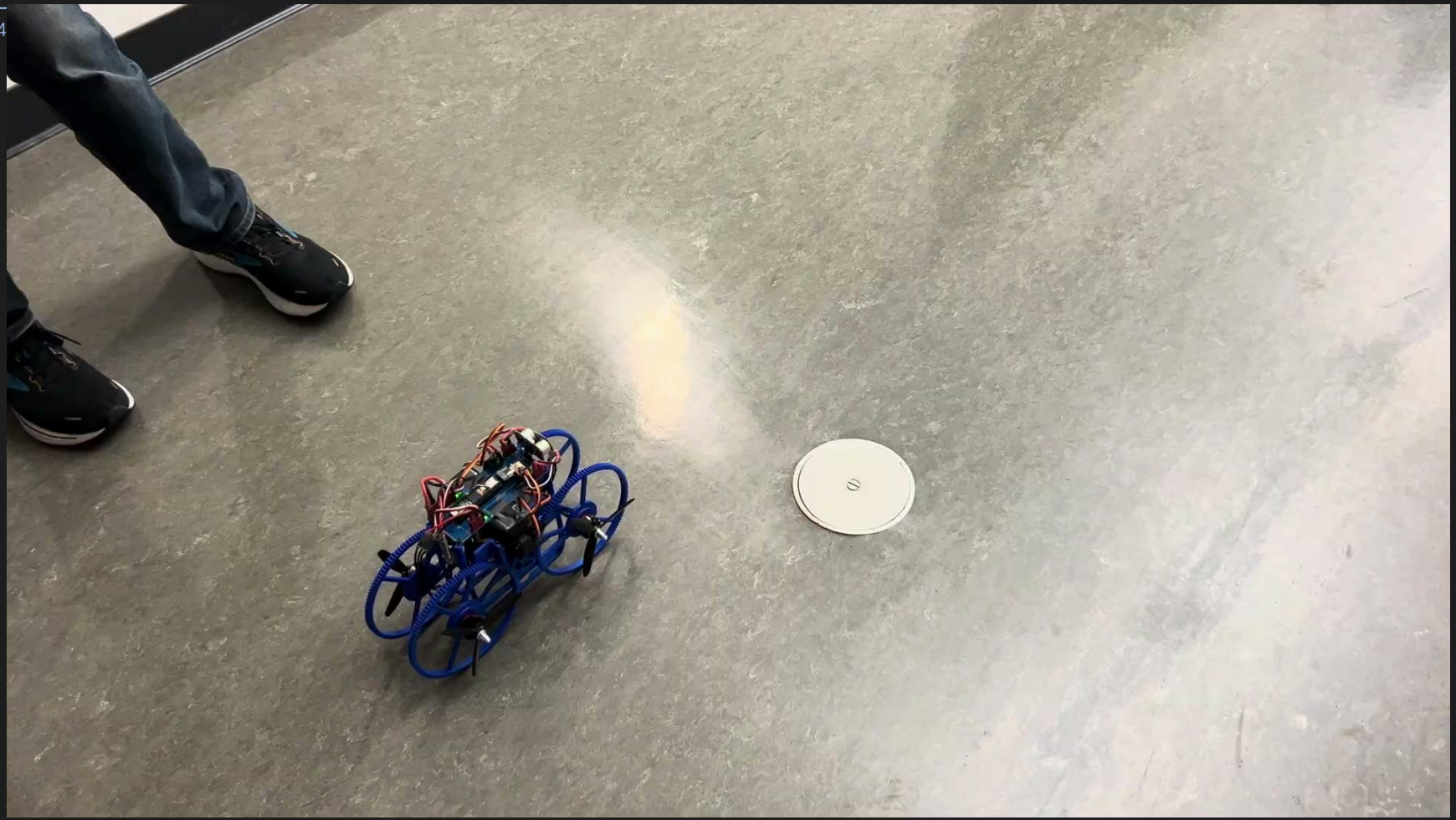
- Exploration of Unknown Environments
- Emergency response in dynamic environments

Lessons Learned

- Embedded systems programming is an optimization problem
- Mechanical integration takes longer than expected
- Electrical issues can occur at any stage
- Control loops are very difficult to debug
    - Mainly due to confounding variables: IMU noise, control loop delay, etc

Stuff

- Original goals
- System design and operation diagrams
- Difficulties
  - Motors / ESCs
  - PID
  - Driving / Traction
  - Turning radius of the moon
  - Nikhils Thumb
  - Noisy data - IMU
  - Power ground shorts through sensors
  - budget
- Improvements/ extensions
- Design implementation scope and rigor
- Sensing actuation planning




Thank
you!!