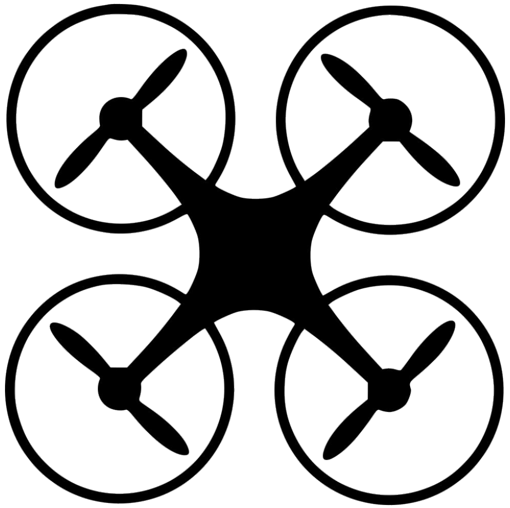


Geofencing for Quadcopters

Alex La, Yeiry Melendez, Kaustubh Kanagalekar

Project Goals

End goal: Implement Geofence boundary for Crazyflie drones with Control Barrier Functions (CBF)

Geofencing: Mapping virtual geographic boundaries onto physical space for collision avoidance

Significance: Create additional safety for Optitrack experiments and possibly outdoor experiments

Video from AMBER- Lab, Caltech for more details on geofencing:

https://www.youtube.com/watch?v=_sCoAdBrgJw

Deliverables

- Explore CBF applications in depth
- Verify CBF formulation with Python plots
- Execute CBF on ROS 2 simulation and hardware

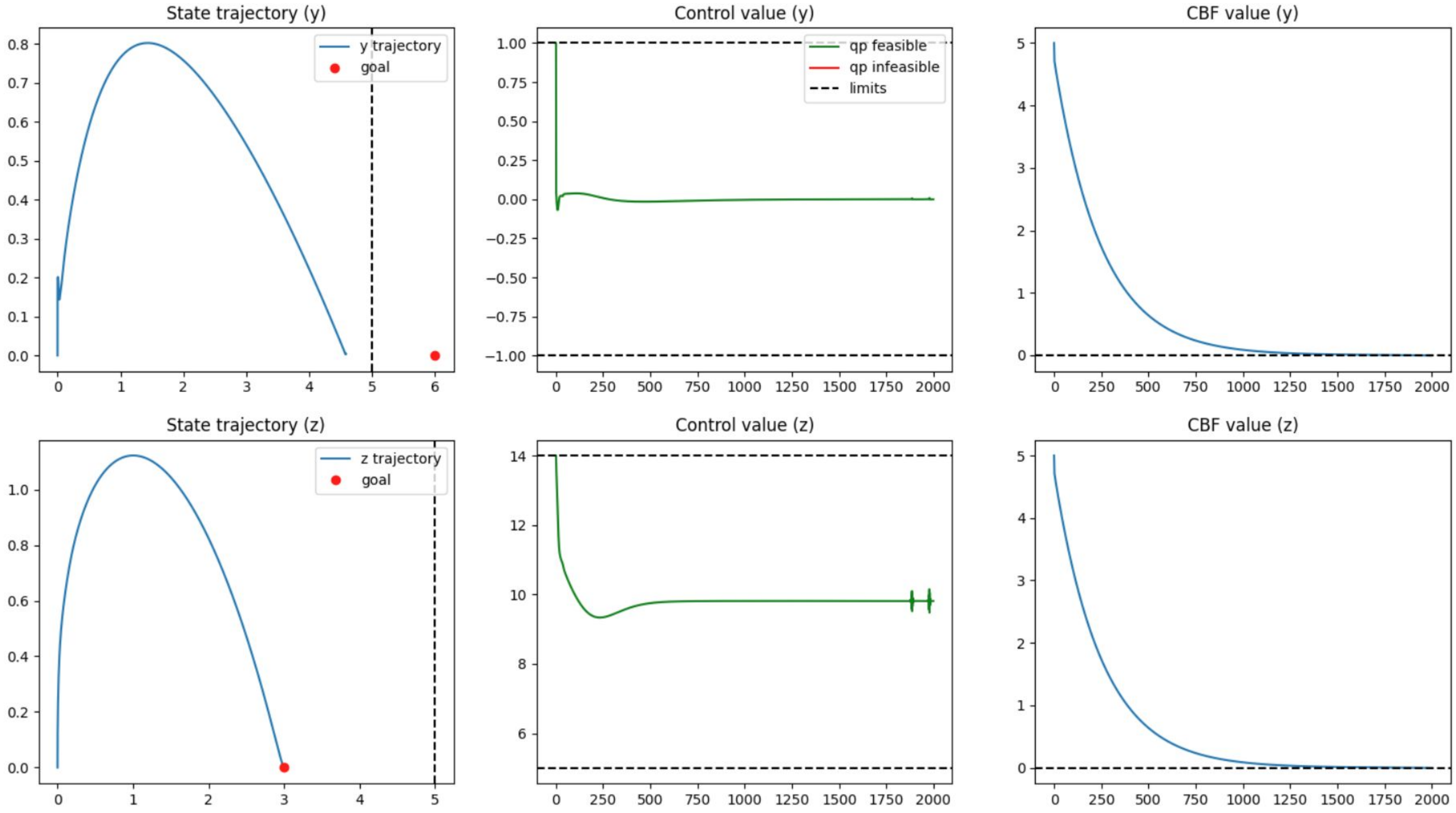
Python Simulation

- Model quadcopter dynamics in Python

- Investigate behavior of nominal control, “naive CBF”, and “hand-designed CBF”

- Tune gain matrix for nominal control heuristically

Python Simulation: CBF results for y and z-axis:



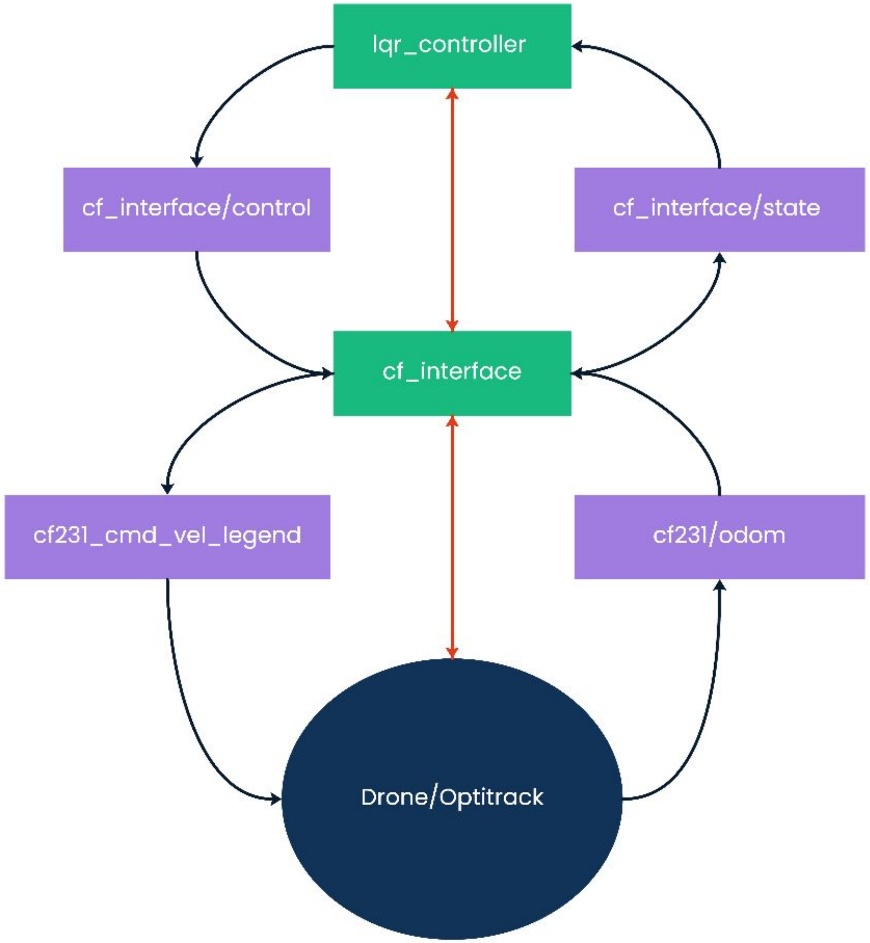
ROS 2 Simulation

Integrate new ROS 2 node: **CBF.py**

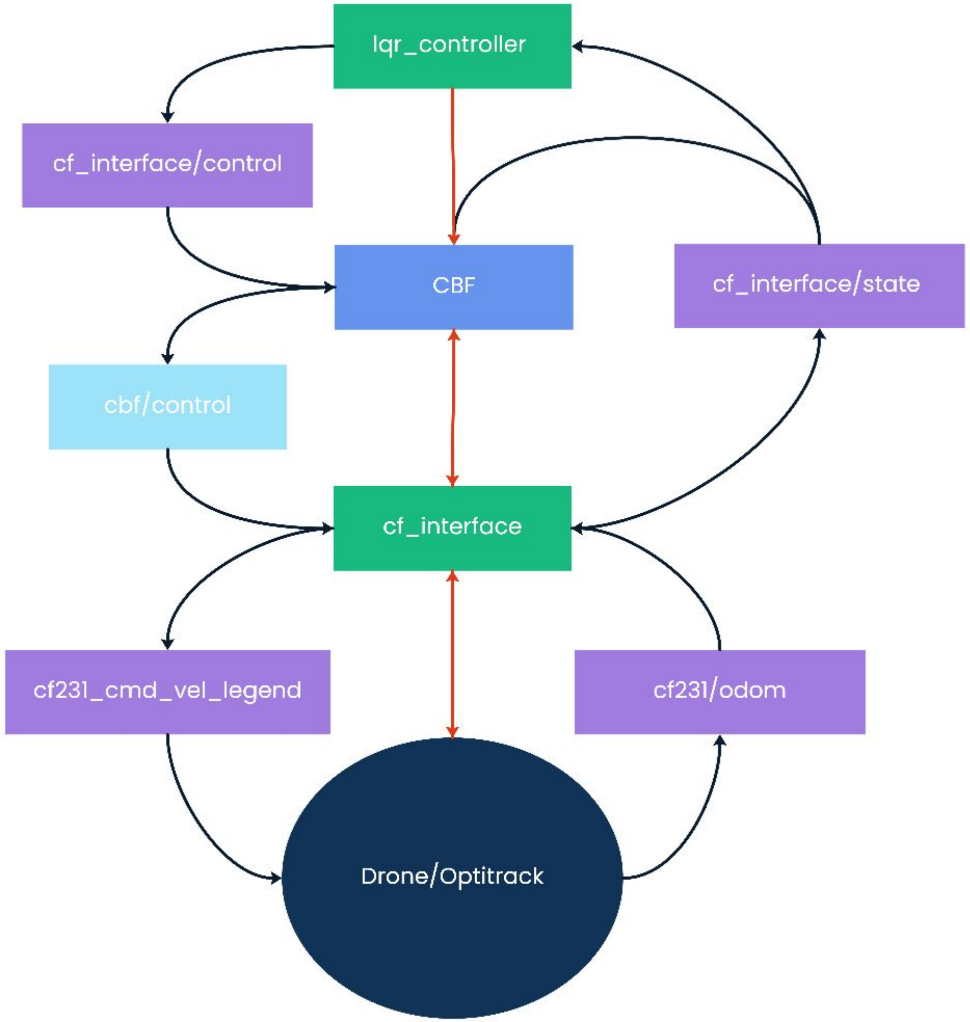
- **Correct** data flow from existing nodes to CBF.py

- Majority of python simulation code in CBF.py

Previous

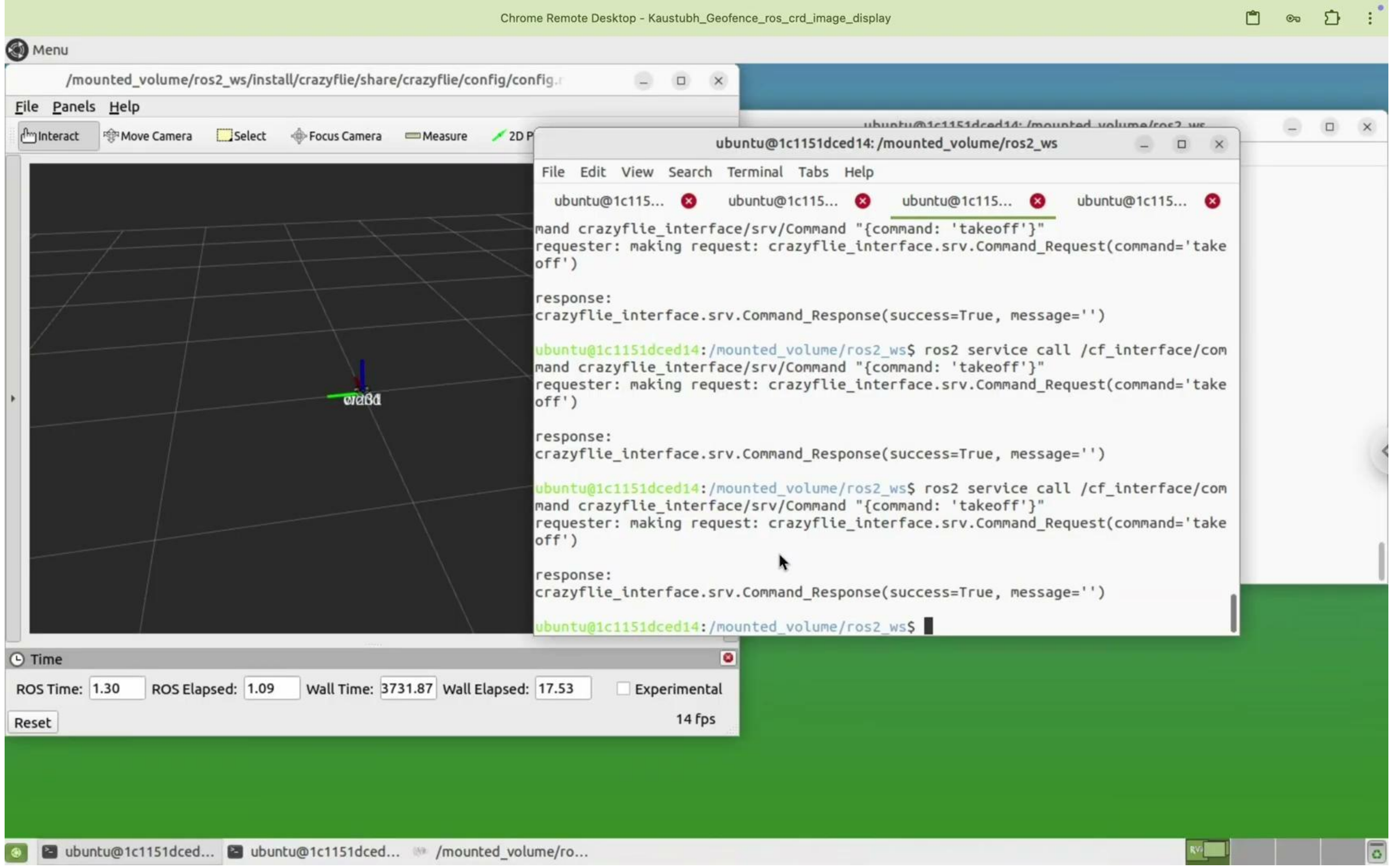


Updated



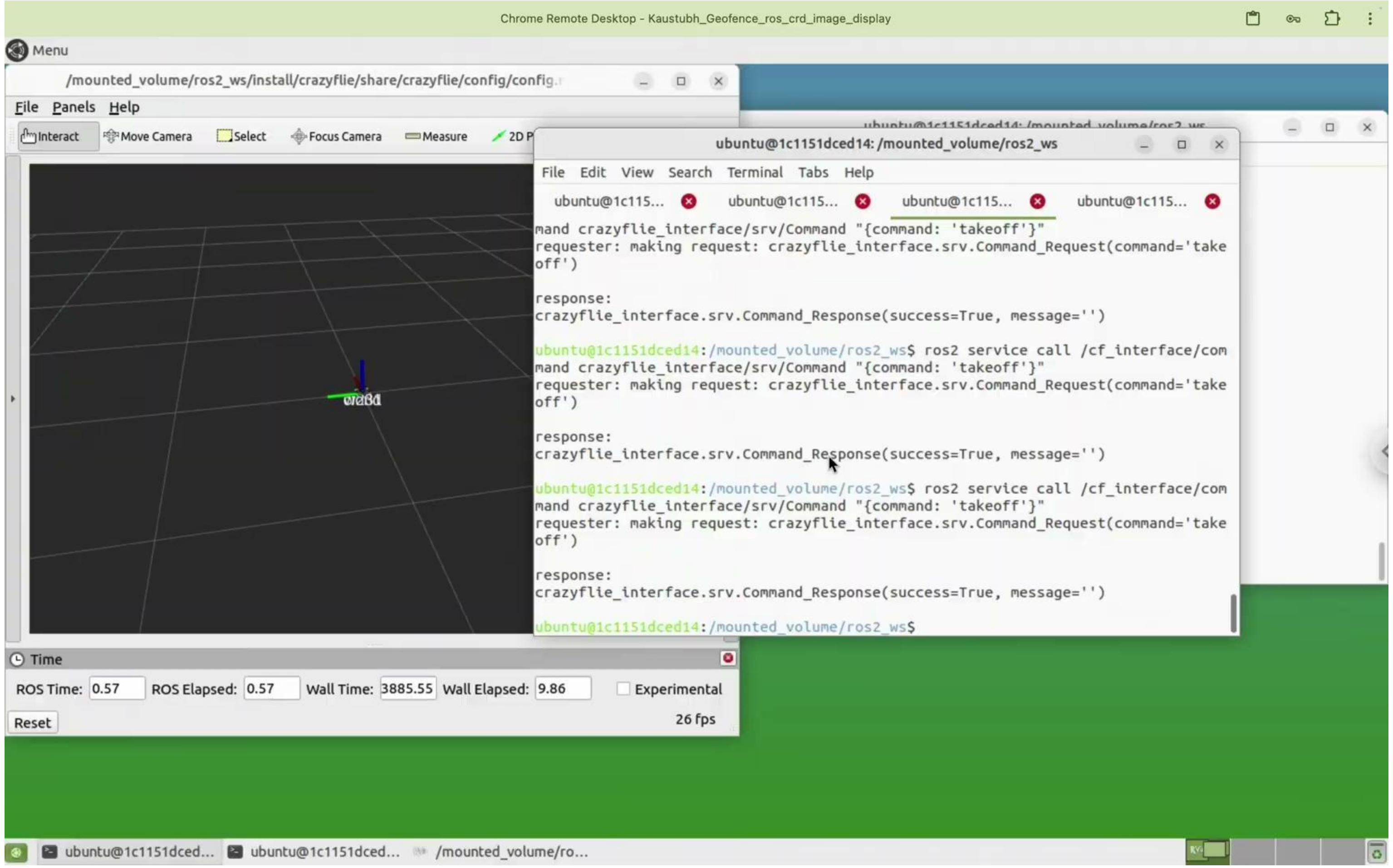
ROS 2 Simulation

Z-axis RVIZ demo:



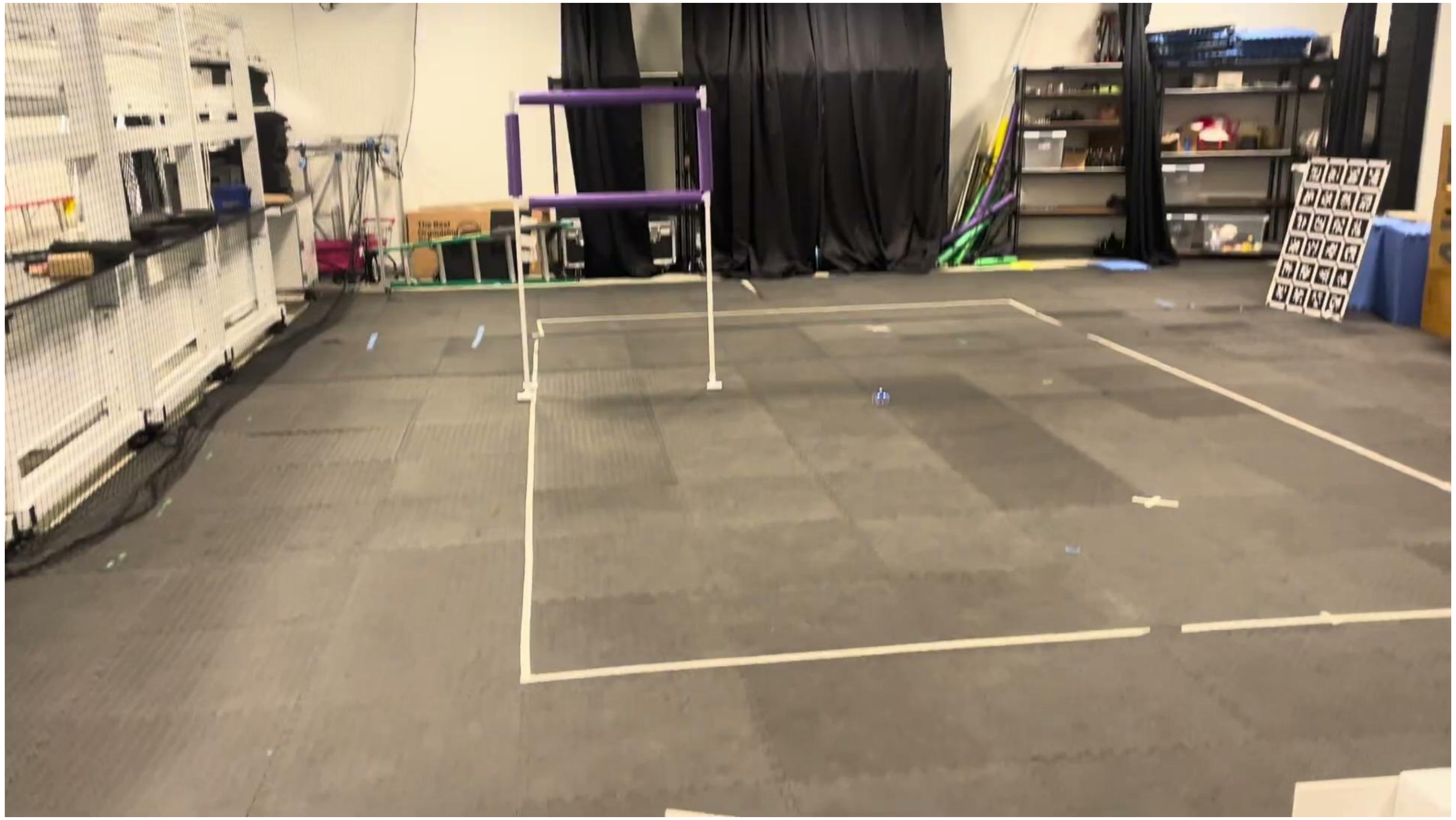
ROS 2 Simulation

Y-axis RVIZ demo



Crazyflie Hardware Implementation

z-axis: without CBF



Crazyflie Hardware Implementation

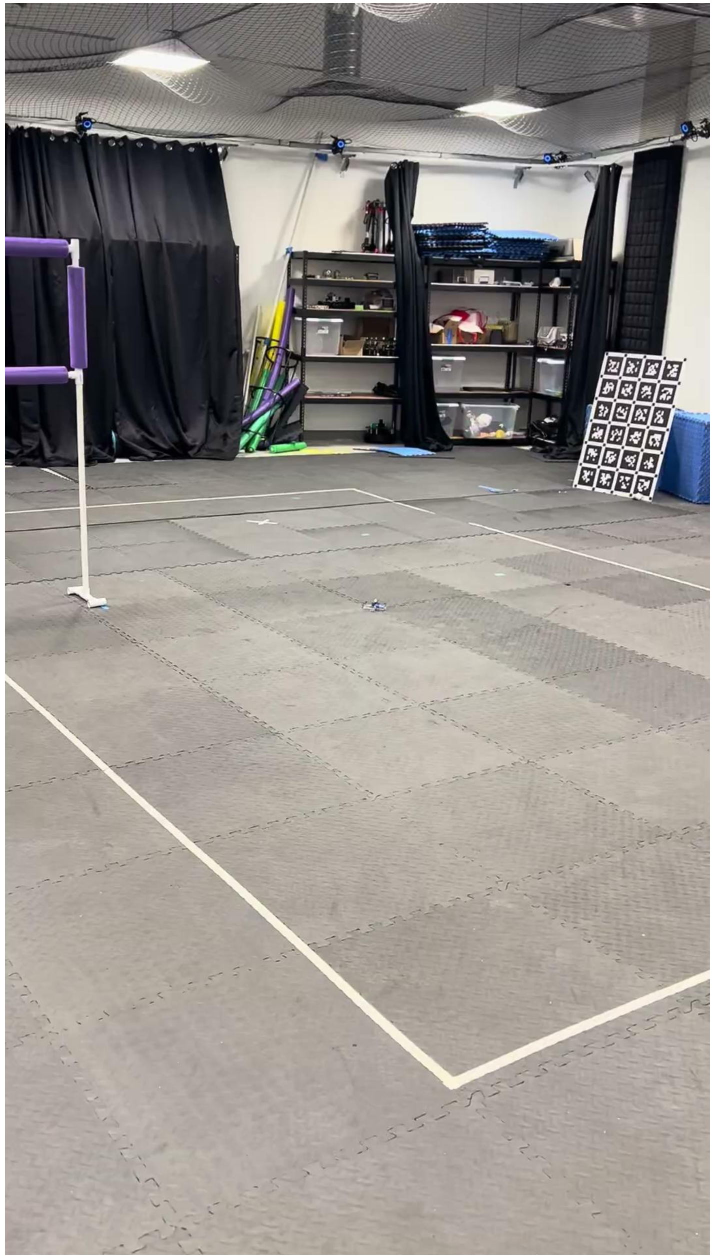
z-axis: with CBF

Crazyflie Hardware Implementation

y-axis: without CBF

Crazyflie Hardware Implementation

y-axis: with CBF



Issues Faced

- Heuristic tuning in Python
- ROS2 simulation tuning
- Planar case (both y-z implementation) in ROS

Future Additions

- Combine y and z-axis CBFs using HJ Reachability

- Spatial movement (3-dimensional position) using Decomposition Methods with 2 planar cases

- Implement into hardware

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