REU Unmanned Aerial Systems With Real-World Applications in Oklahoma

Vision-Based Control of Unmanned Aerial Systems

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Technical Mentors: Dr. Merchan-Merchan & Dr. Sun

Outline

Outline Cont.

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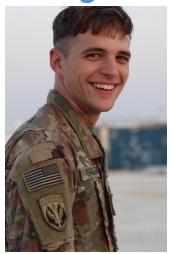

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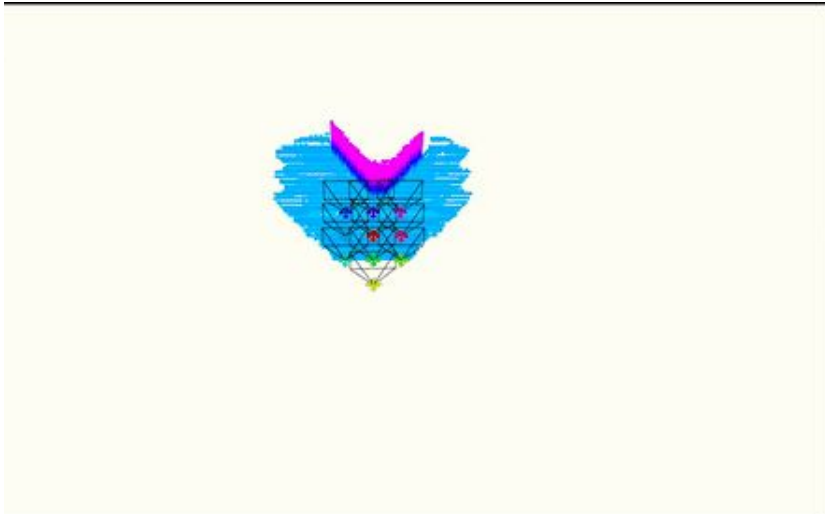
Problem Background

- Contemporary drone systems do not typically use multiple sensor fusion to estimate position and orientation in a swarm setting. Nor do they use only monocular cameras.
- Navigation systems typically use complex and "heavy" sensors, which are traditionally difficult to mount on a small drone, and require additional setup.
- Current studies don’t focus on use for systems “out of the box.”

Problem Background Cont.

- A team of agents provides redundancy and allows for a split effort towards mission completion.
- Depending on the specific task, additional agents can reduce the time to completion by half or more.
- Additionally, the use of multiple drones may be able to perform tasks that a single drone could not perform at all.



Problem Background Cont.

Definitions:

- Leader-Follower System:

A leader is an agent that follows a specific task such as for example following a path and the followers are a swarm of agents that only care about following the leader agent.

- Unreal Engine:

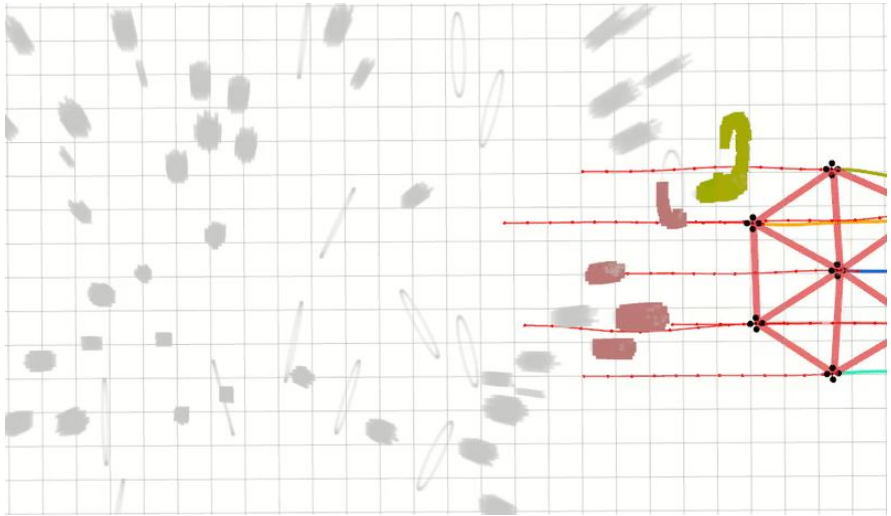
Unreal Engine is a physics and graphics platform that Microsoft AirSim uses to simulate how a leader-follower system will behave in our case.

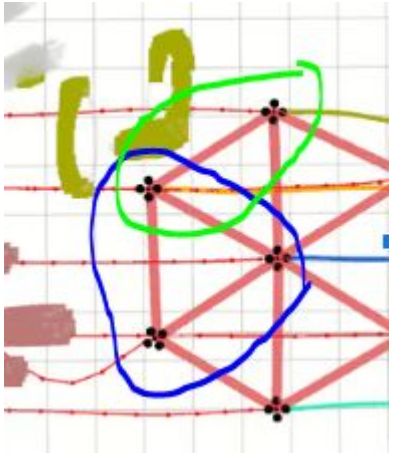
Problem Background Cont.

- We have the technology

Problem Background Cont.

- We have the technology





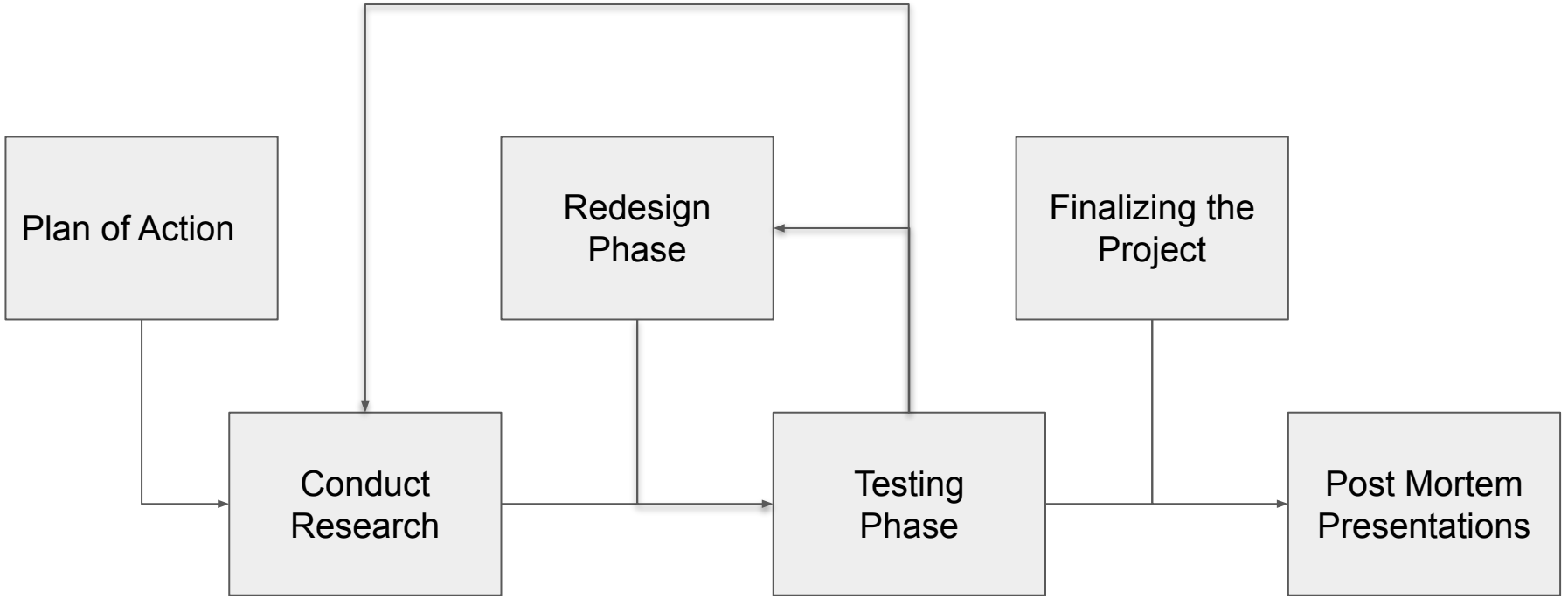
Problem Statement

- The system should facilitate the fusion of each of the agents' single-mounted cameras in order to determine the relative states of each agent.
- Additionally, the swarm shall be able to move as a single unit, which may be based on leader-follower strategies with individual agents that may use flocking algorithms.

Deliverables:

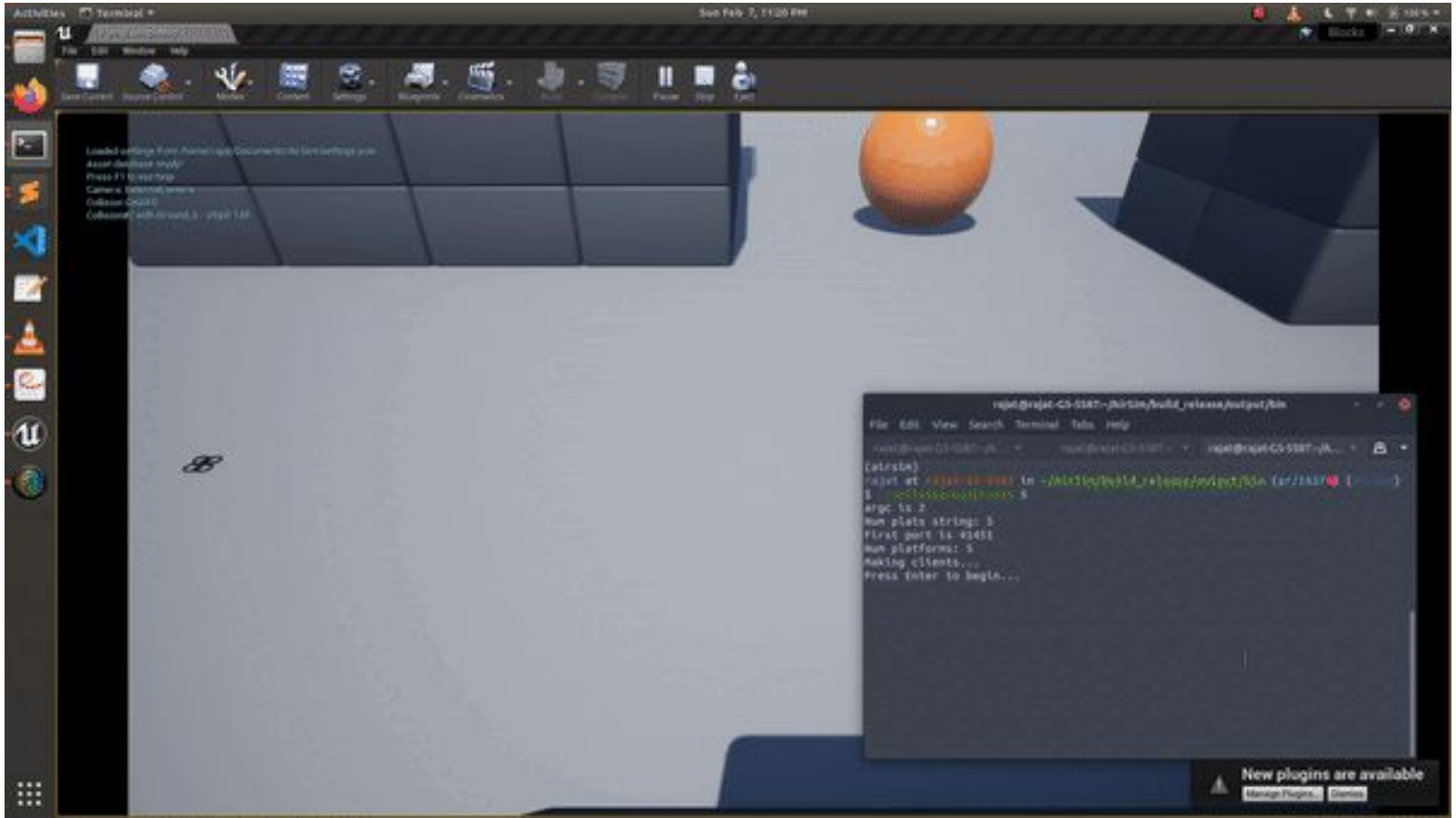
- Design a system that can satisfy a multi-agent drone swarm with vision-based autonomy.

Research Process



What we've done

- Successfully set up a drone simulator (Microsoft Airsim)

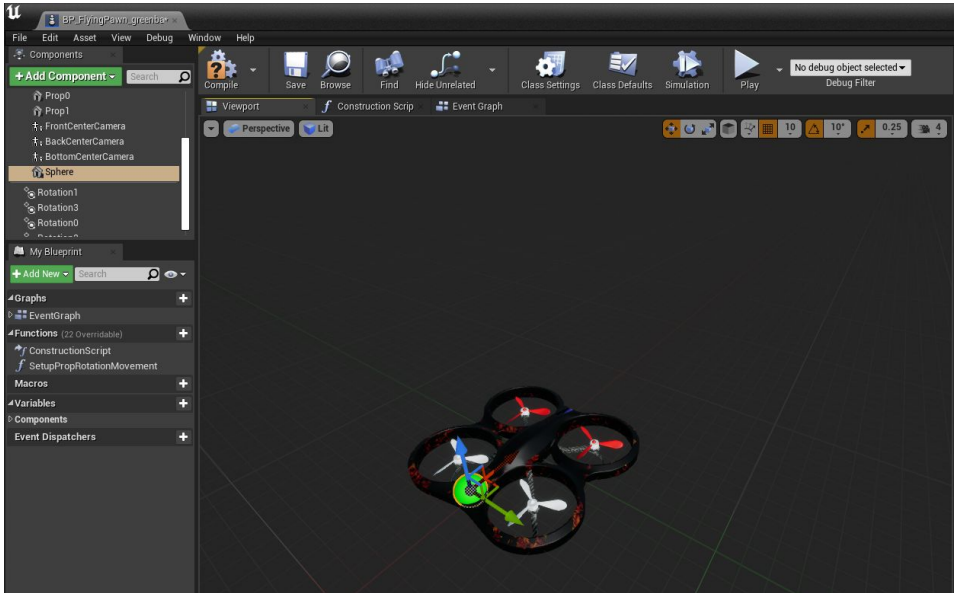


What we've done cont…

- Created a code abstraction for manual control of drones as we would control a DJI Tello EDU

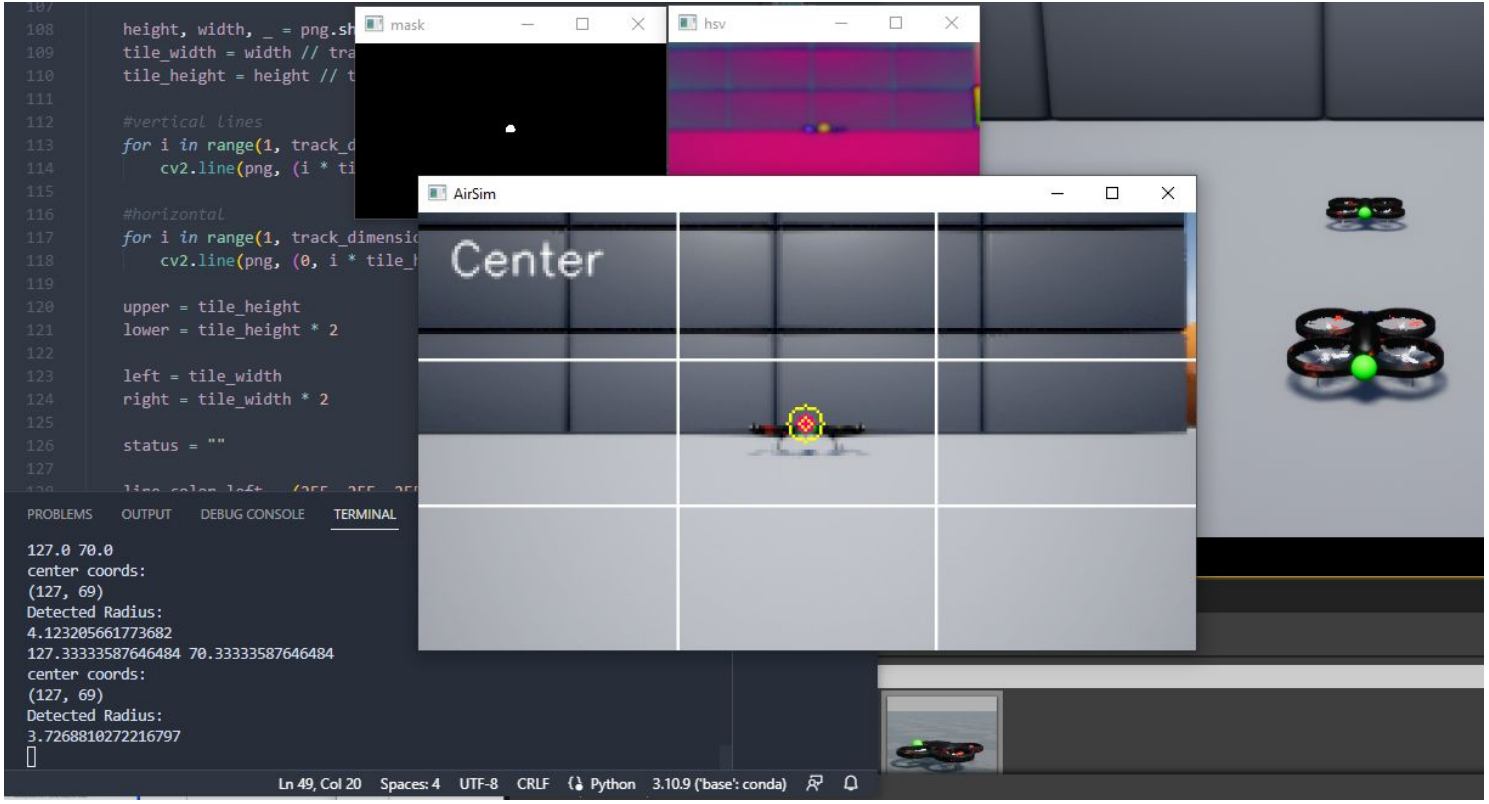
What we've done cont…

- Modified the 3D-Model in Unreal Engine to have a easily-trackable green ball



What we've done cont…

- Used OpenCV to import virtual camera feed for a tracker controller
  - Determine threshold boundaries, min max radius, for adjusting follower position



What we've done cont…

What we've done cont…

Leader-Follower Object Tracking

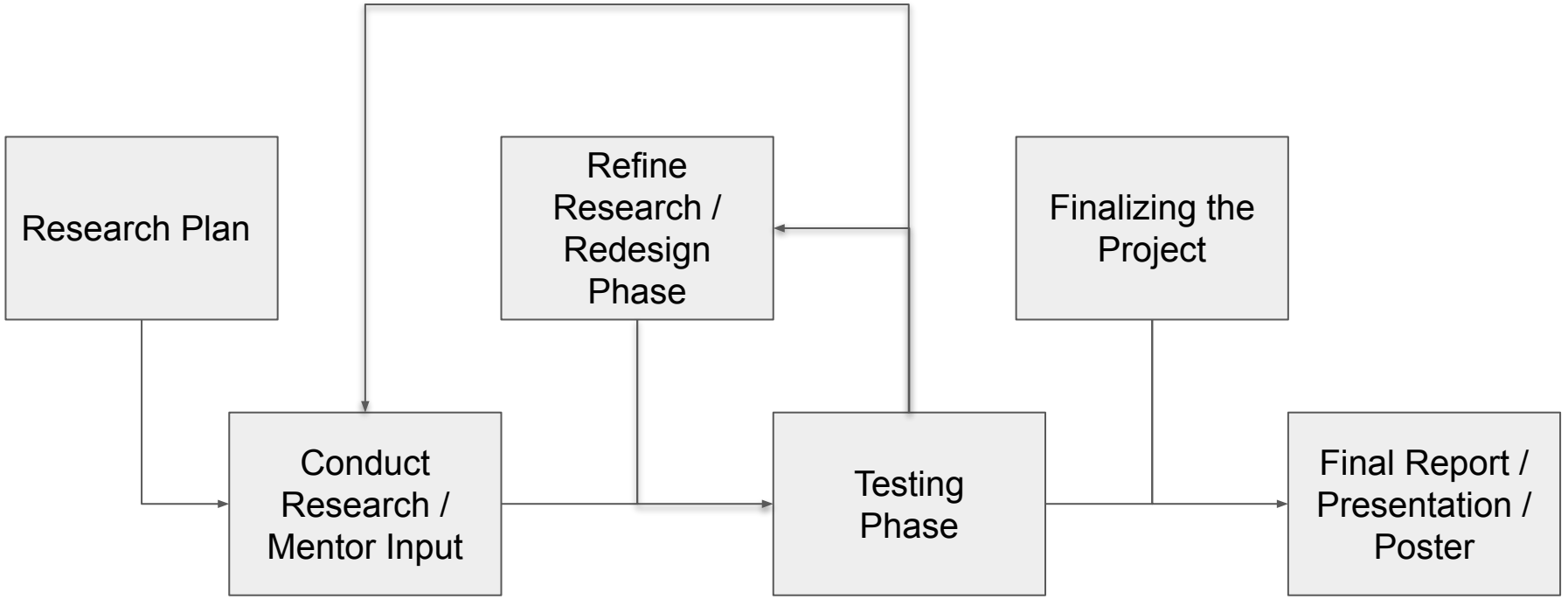
What we've done cont…

Leader-Follower Object Tracking Cont.

Value Added

- Value to the Project
  - Established visual capability for swarm behavior
  - Provided a framework that will be useful in visual formation control
  - Modular logic transferable to future developments (switching ball detection for drone detection will be “plug-and-play”)
- Value to the Intern
  - Learned how to transfer solutions from simulation to physical implementation
  - Experience using perception frameworks
  - Gained knowledge of 3D models in Unreal Engine

Research Process (Plan for Future)



Research Process (Plan for Future)

Next Steps…

- Developing controller for >2 agent systems
- Create a formation changing scheme
- Exploring threading and other options for a more seamless controller
- Using machine learning for drone detection and tracking
    - Possibly using some new developments on optical flow and feature tracking

Items for Project

- DJI Tello Edu Drone (x3)
- PC to test drones in Microsoft AirSim
- Laptop capable of running Linux

Broader Impacts of the Research Project

Engineering Experience:

- OpenCV, Python, and Microsoft AirSim Experience

Financial Benefits:

- Forgo expensive sensor attachments for tasks that don’t need them

Environmental Impacts:

- Mapping out GPS restricted areas

Reliability/Safety:

- Search and Rescue
- GPS Restricted Areas (Canyons, Dense Forests, etc.)

Intellectual Merit of the Research Project

- Attempting to use existing perception technologies in ways that haven't been extensively developed yet.
  - E.g. Using real time YOLO object detection as a means for follower-pursuit.
- Development of algorithms in a constrained platform would allow for future improvements on a less-constrained system.
  - E.g. If a test with the current setup takes 20 seconds supposedly, a system with more freedom of maneuver would likely be more efficient.
- Modularity of the design could allow multiple different object detection/tracking techniques to be swapped out and tested.

Conclusions

- Difficult problem space, constrained to 1 sensor in one direction
- Drone Limitations
  - limited to six degrees-of-freedom holonomic movements
  - rely on udp network messages for commands (one way message traffic)
- Tracking by object color is unreliable
- Vision based control is becoming more feasible with recent advances in perception algorithms

Q&A