TEXAS A&M UNIVERSITY
Engineering

Autonomous Combat Vehicle

Final Presentation

MEEN 402
Dr. Dale Cope
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Introduction

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What is Game Theory?

- Mathematically models human decision making in complex environments, which is ideal for analyzing complex military situations.
- The research project's ultimate goal is to utilize Artificial Intelligence (AI) to demonstrate game theory by playing the Capture The Flag (CTF) game autonomously.

Sponsors & Stakeholder

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Dr. Korok Ray

Primary Sponsor

Dr. Sivakumar Rathinam

Budget Approver

Mr. Yan Yao

Technical Advisor

Dr. Guni Sharon

Stakeholder

Motivation

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Autonomous Combat Vehicle Research Project

1st step: Yan Yao built Donkey cars (some manual control and fire mechanism)

2nd step: ACV Team developed Donkey cars to play one versus one Capture the Flag (CTF) game (full manual control, IR Blaster and receiver, and capture the digital flag)

3rd step: Computer Science department team (stakeholder) will implement AI capability to the Donkey cars and demonstrate the game theory to the US Army

Mission Statement

Design a scenario for RC cars to play a one vs. one Capture The Flag (CTF) game where the RC cars have manual control and hardware ready for AI capability.

Customer Needs

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1. Arena is South west Innovation Research Lab (SwIRL)

2. The Donkey cars operate with full manual control

3. The Donkey cars have the capability of a plug-in for Artificial Intelligence (AI) control

4. Capture The Flag (CTF) game must be functional with fire and CTF mechanism

Project Structure

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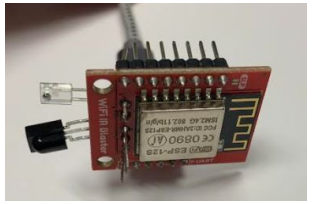
Four Main Tasks:

- Physical Car & AI Hardware

- Manual Control



- Shooting and Receiving with IR Blaster

- Capture The Flag Mechanism Using a Camera

Physical Car Chassis Adjustment

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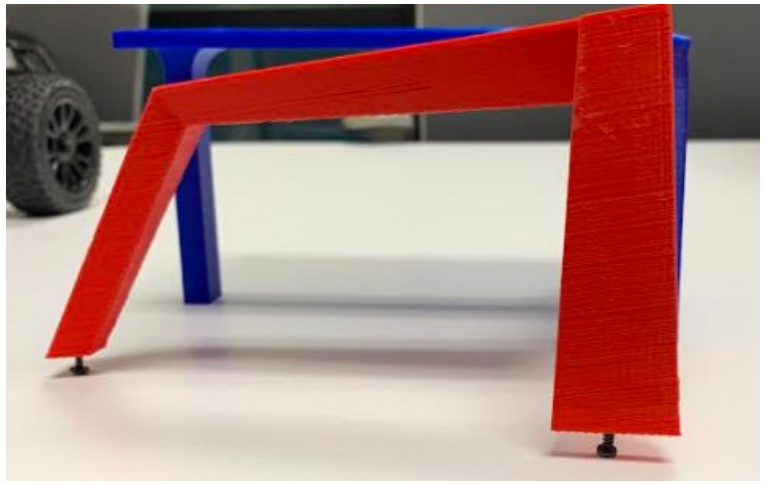
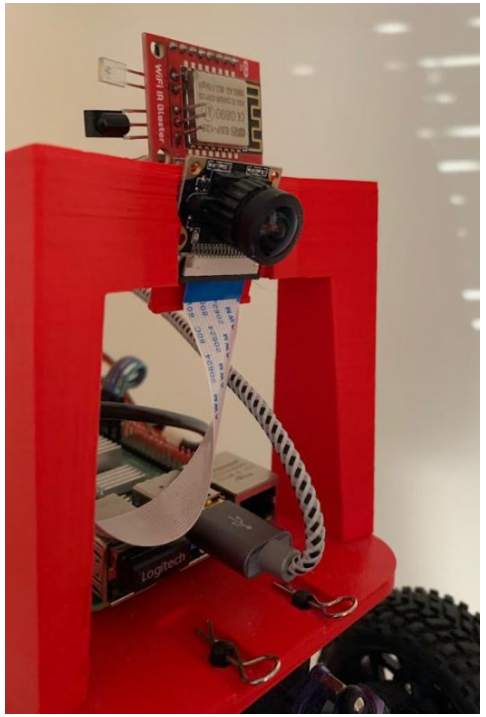
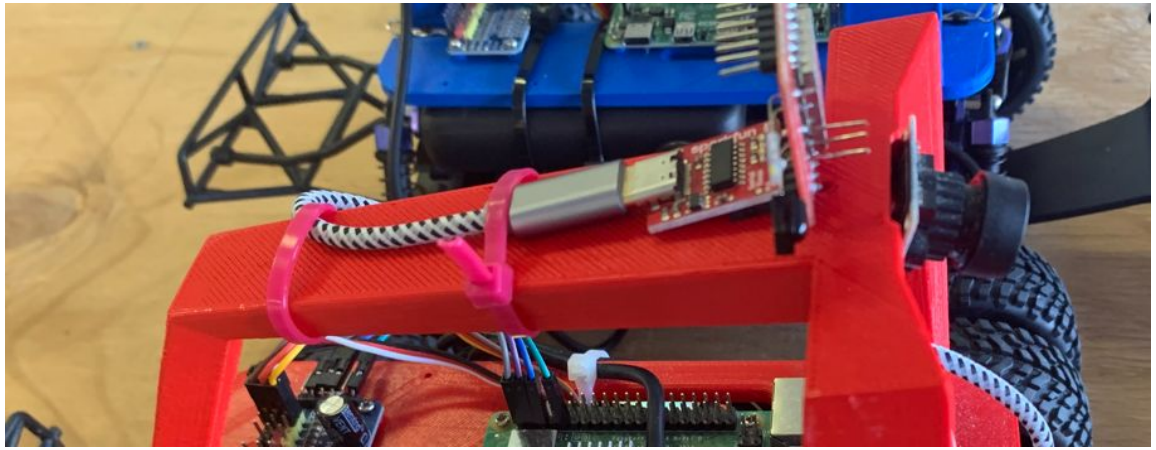
The status of what we inherited...







...and weird angles!

...with Zip Ties!

Chassis Adjustment

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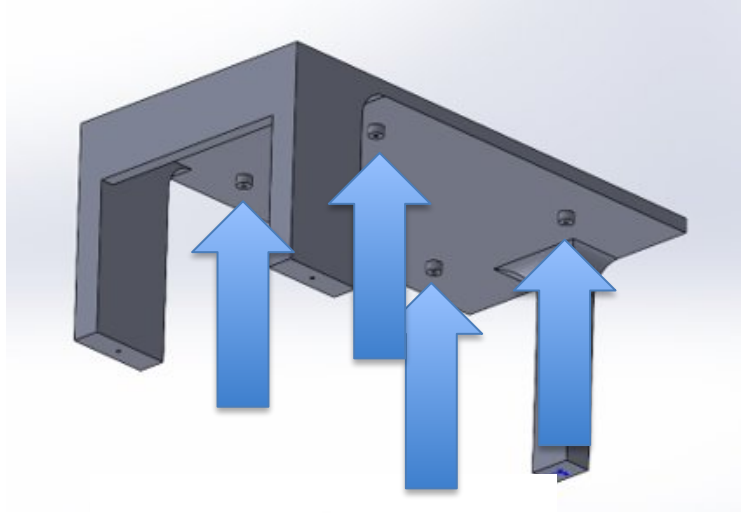
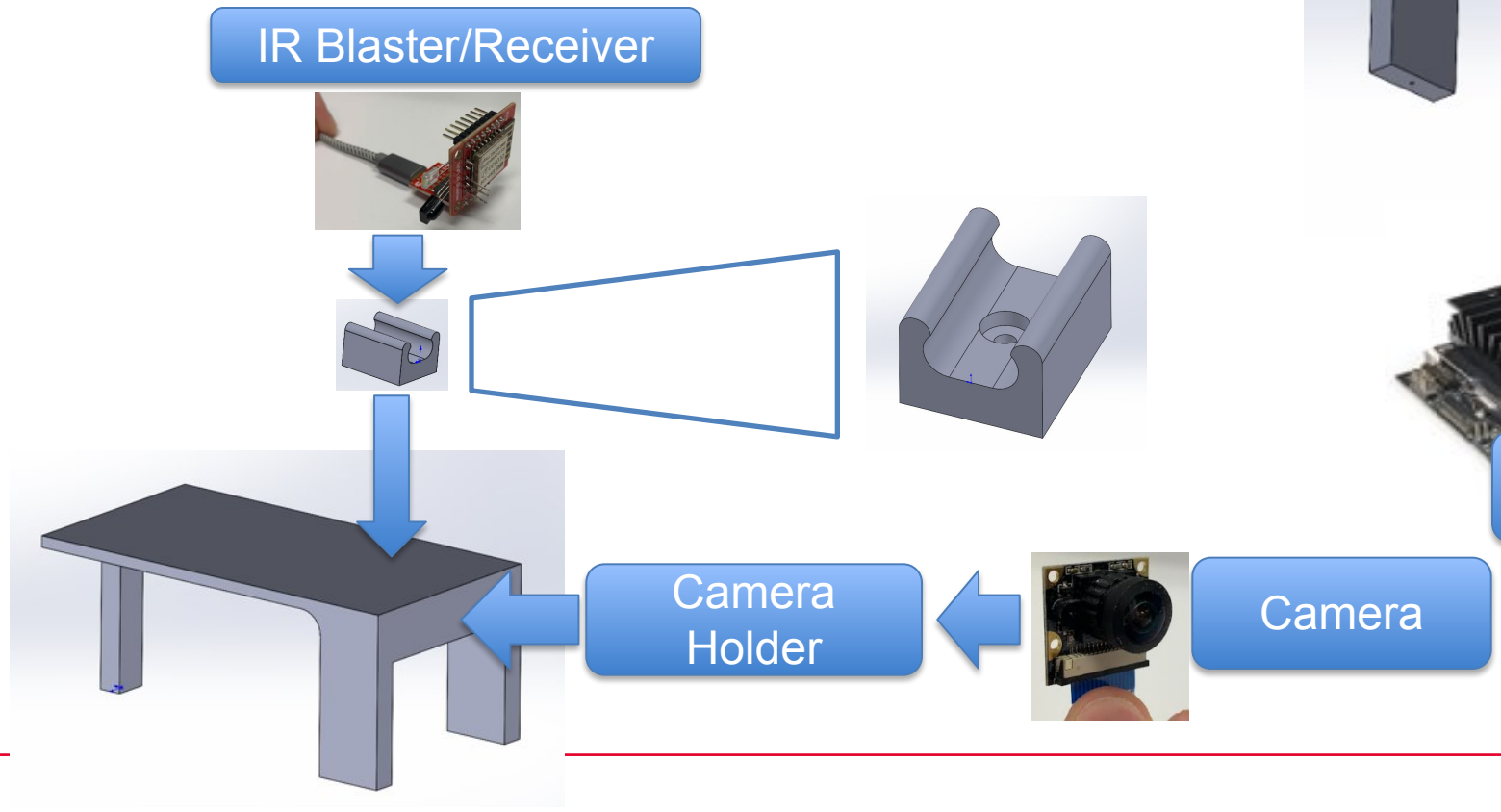
What do we need it to do?

Modular flexibility to fit:

IR Blaster/Receiver | Jetson Nano | Camera





Chassis Adjustment

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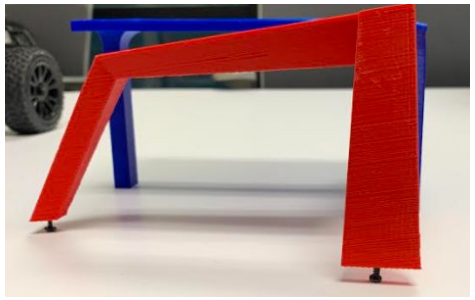
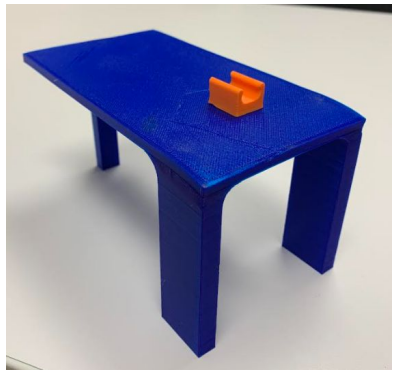


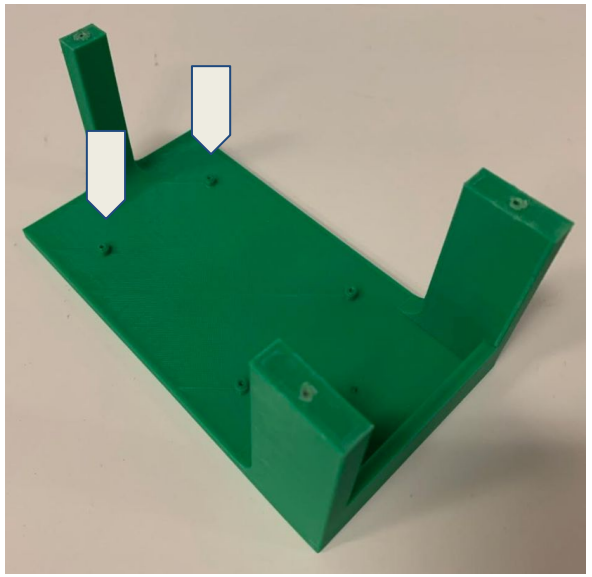
Original Chassis,
90 degree angles!

The progress....

...in Red



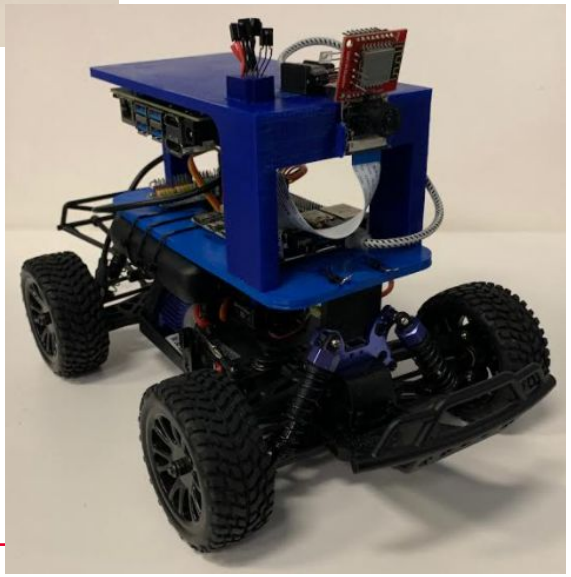
1st Chassis,
90 degree angles.



2nd Iteration, bottom stanchions & camera mount

Final Iteration...

...and in Blue



Chassis Adjustment

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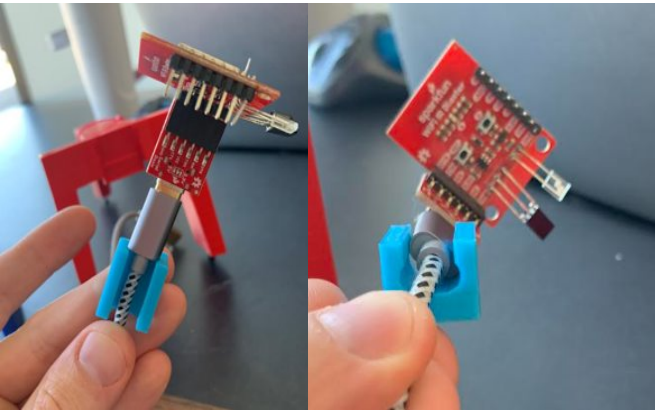
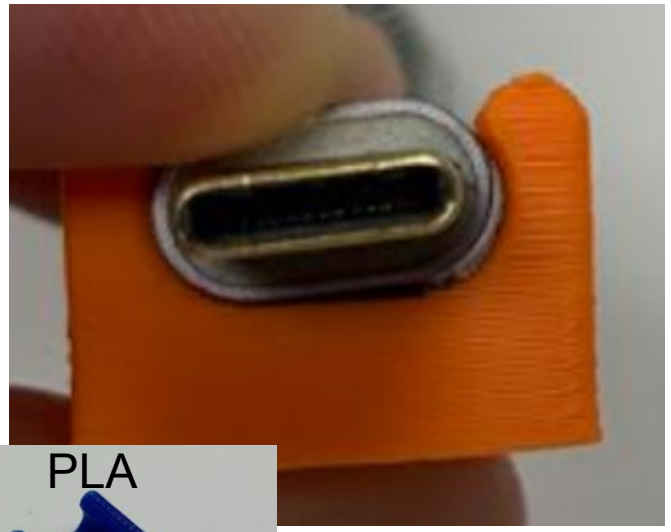
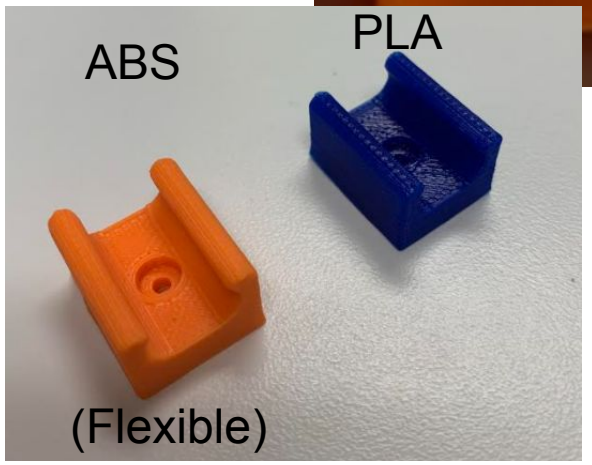


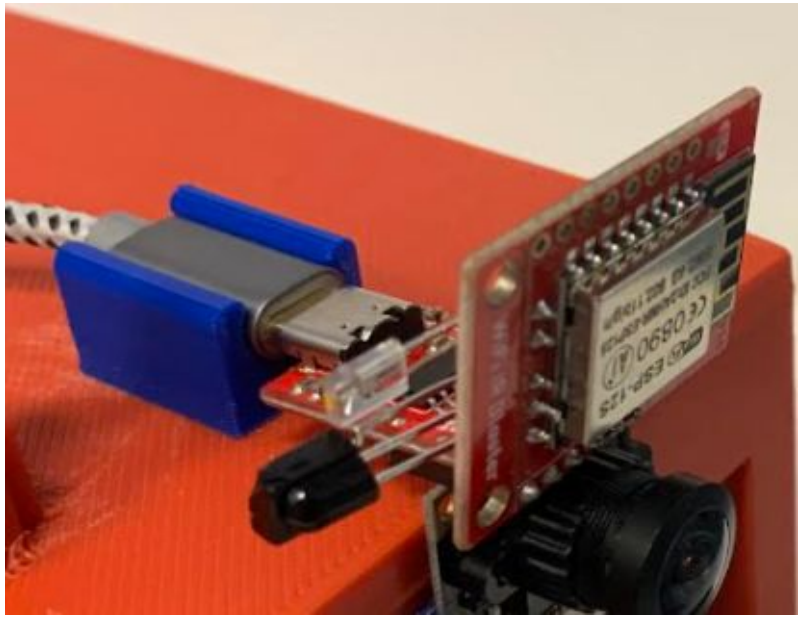
...1st Iteration MM's Too Small!

IR Shooter Clip



...2nd Iteration, MM's Too Big!





Final Iteration, Snug fit

IR Shooter/Receiver

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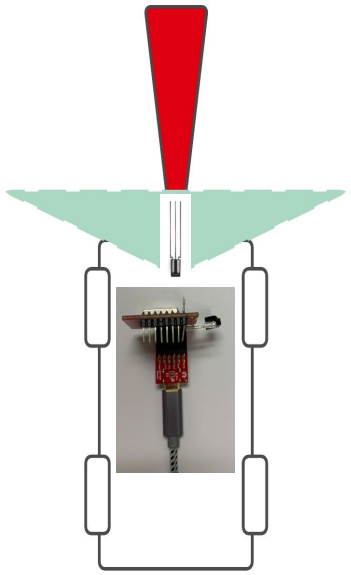

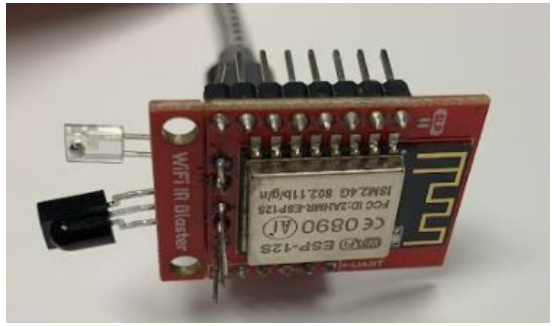

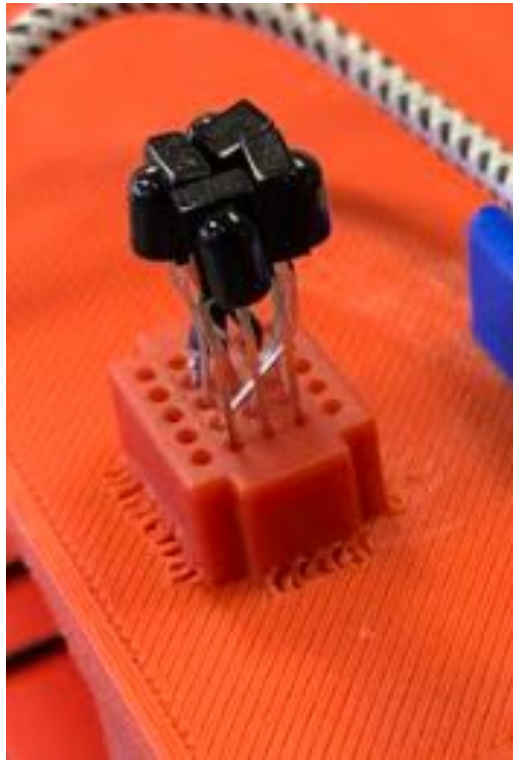

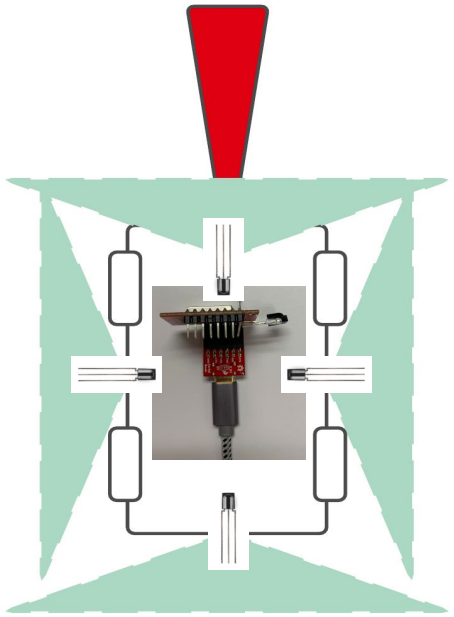

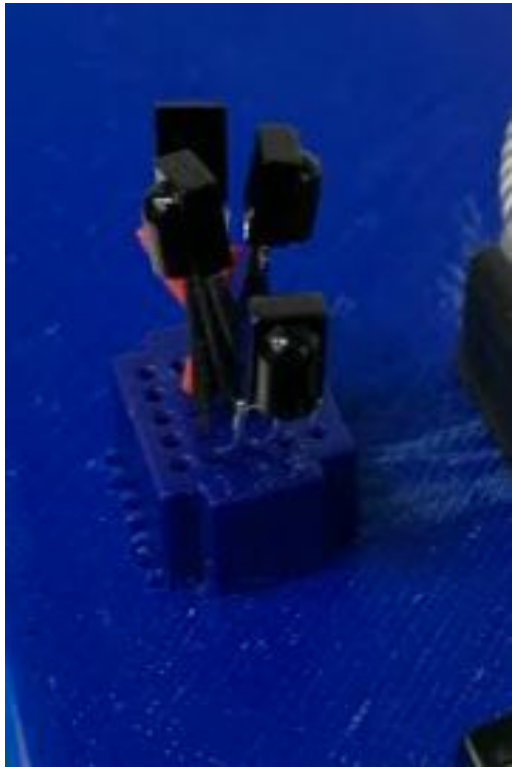

Chassis Adjustment

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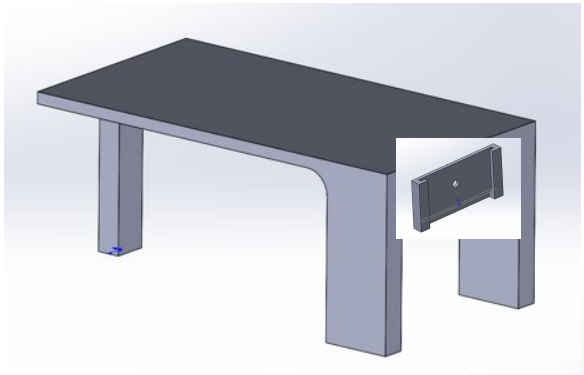
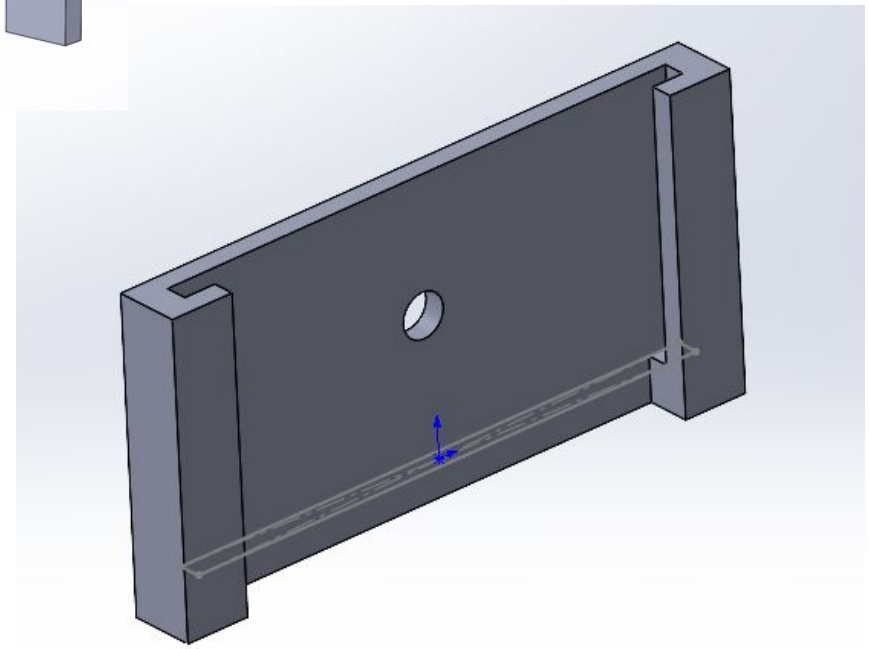
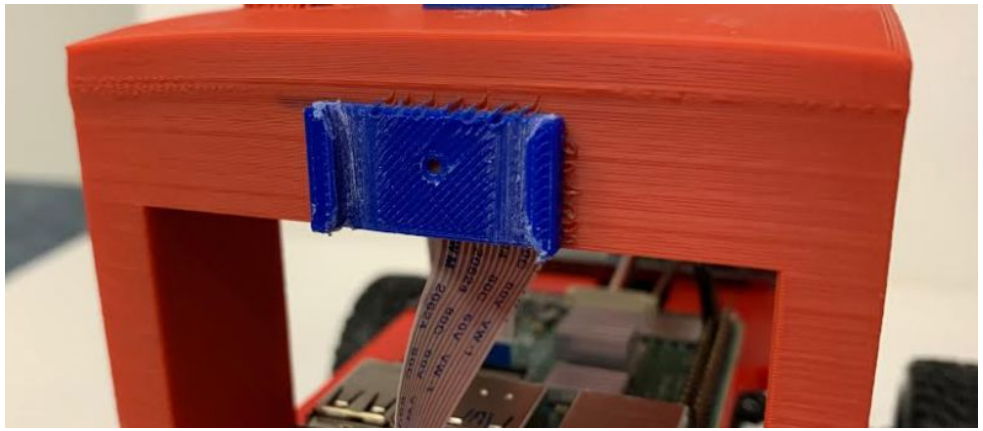
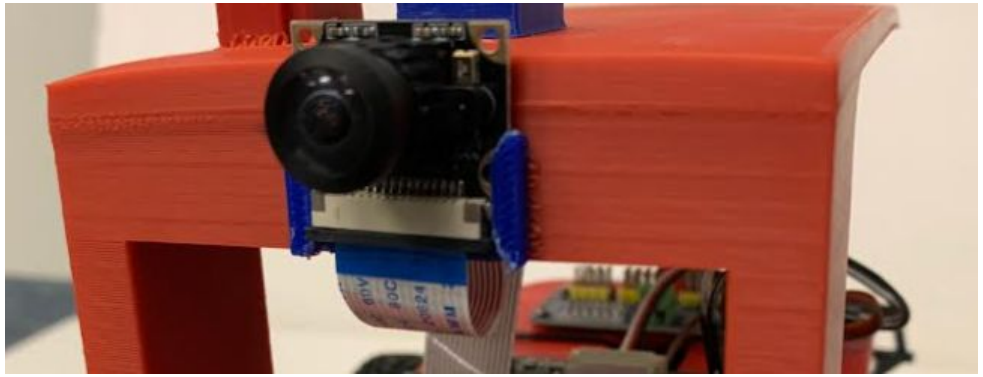
Camera Holder









Chassis Adjustment

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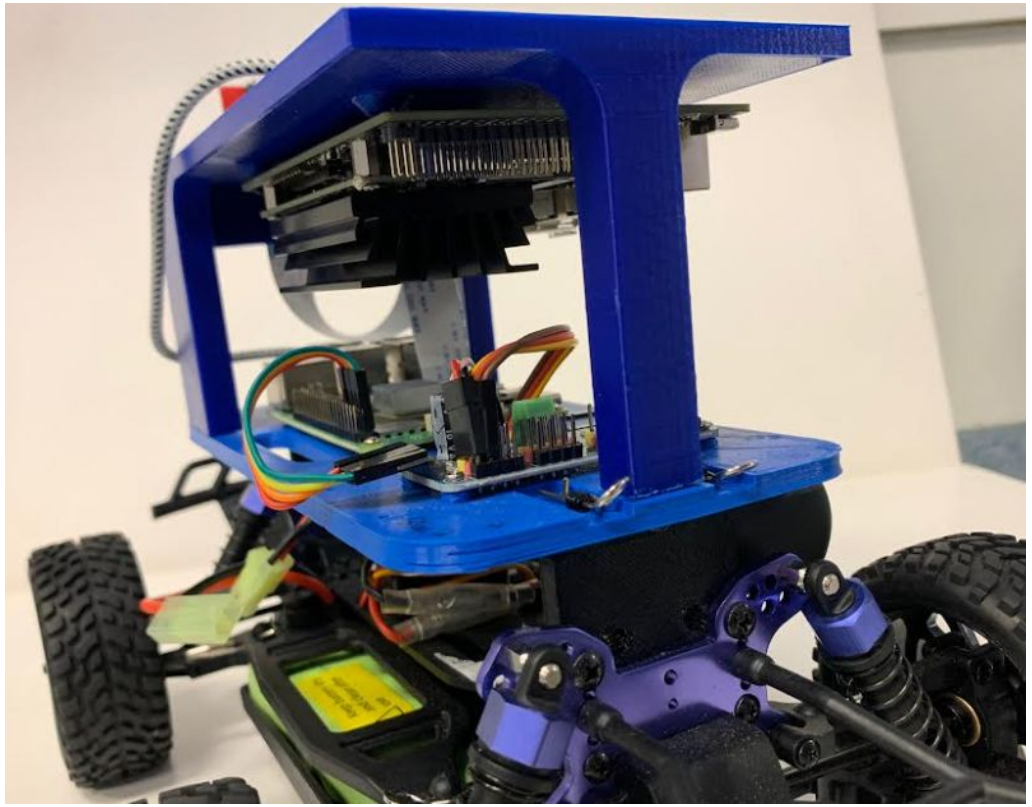
Jetson Nano Attachment



Chassis Adjustment

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ROS Background

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What is ROS?

- ROS is not a real operating system (more like a communication hub)
- Different nodes (python and c++) can communicate to each other

ROS Background

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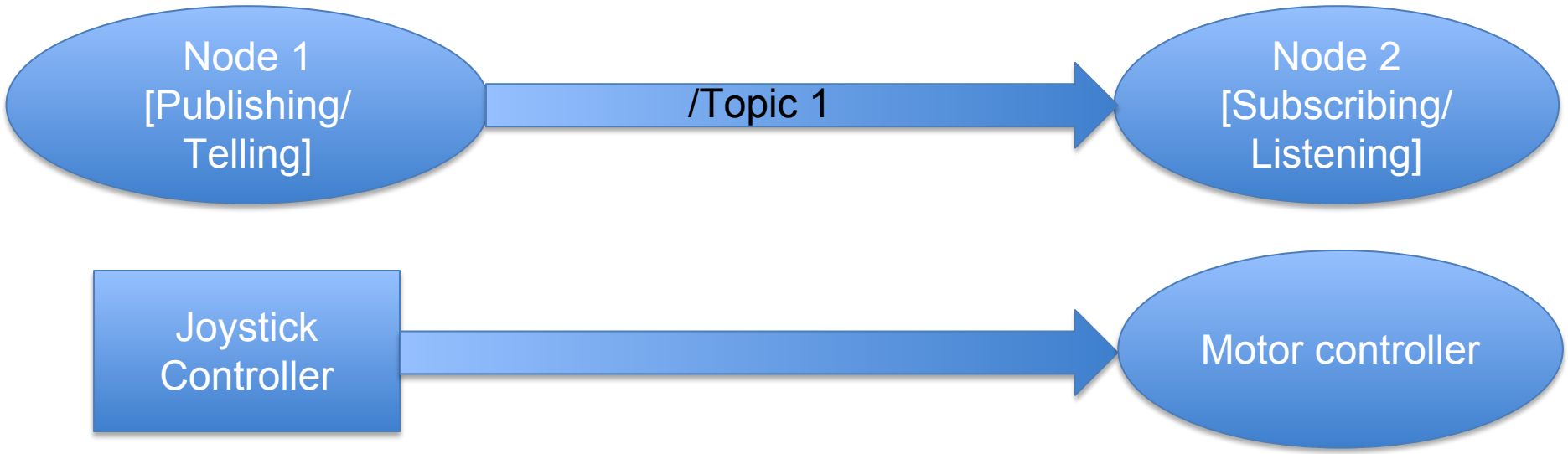
Basics of ROS Communication



Manual Control Plans

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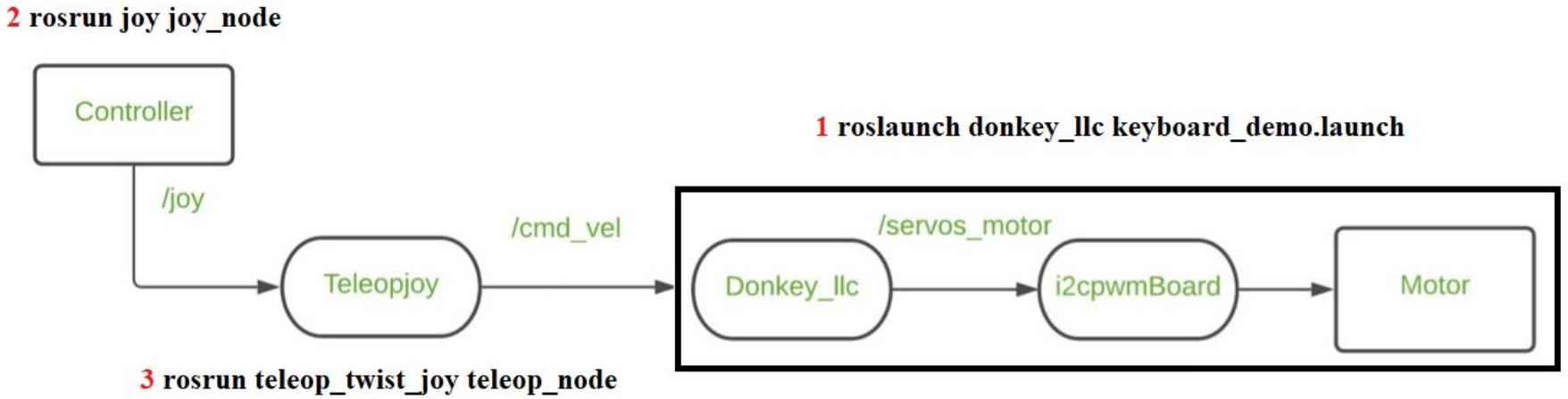
How does manual control of the Donkey car work?

- Nodes, Publishers, Subscribers, and Topics (example)
- 3 major commands used
  - 1 is used for the car servo and motor
  - 3 is used for motion (velocity and turn angle)
  - 2 is used for the controller and its keys



Challenges in Manual Control

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- Troubleshooting
  - Errors can arise, but patience is the key to moving forward
  - Research must be done (ROS Wiki, Stack Overflow) to understand and fix errors
  - Common errors faced when missing/building packages, forgetting about nodes, and incorrectly typing commands
- Networking
  - Connecting to a local network vs. Using an access point
    - Dynamic vs. Static IP address (no more pinging!)
    - Pi-Fi connection vs. Car Wi-Fi

Final State of Manual Control

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- The team has successfully gained manual control of the cars
- 2 cars are completely done, being able to be controlled with keys on the Logitech controller (1 vs. 1)
- Key re-mapping was done to allow the cars to be operated like modern racing and shooting games

IR Shooter/Reciever

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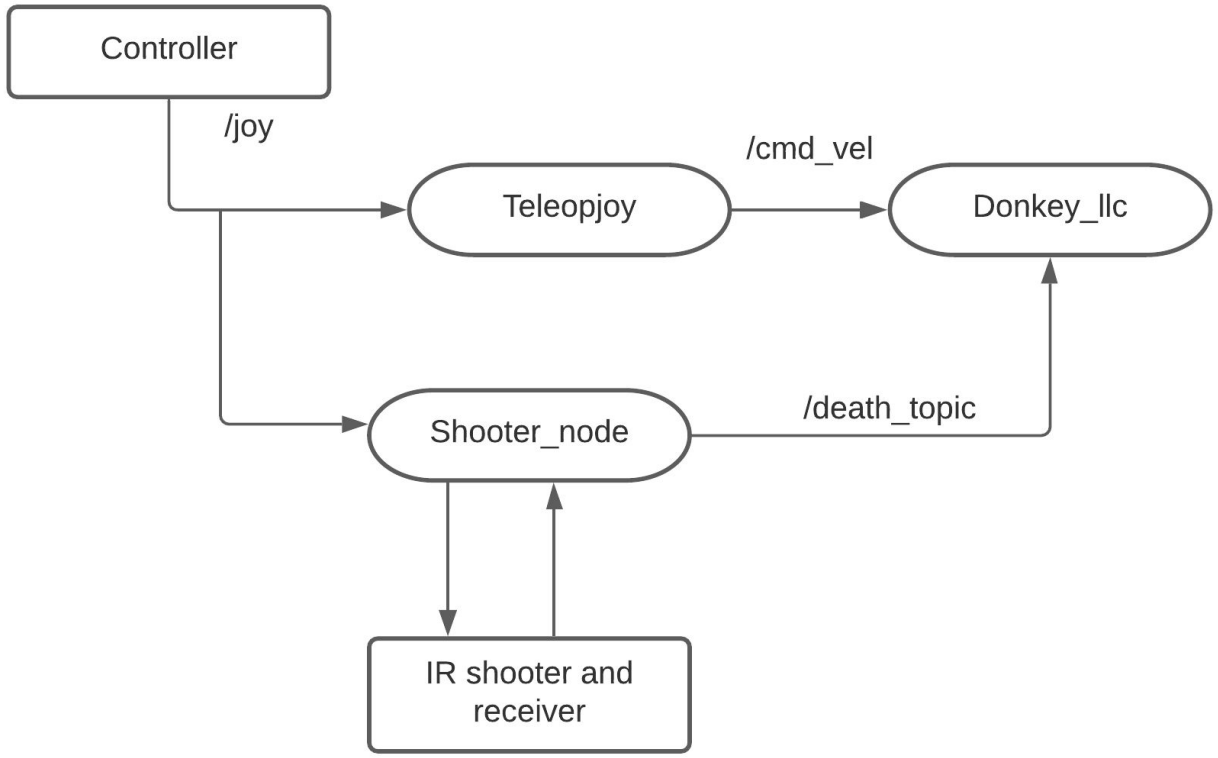
- Shooter_node (Python):

  Command the IR Blaster to shoot and detect incoming shots

  Subscribe: /joy

  Publish: /death_topic



Capture The Flag (CTF)

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- OpenCV (AI Library):

  Computer Vision Library used for color or QR code detection

  Subscribe: None

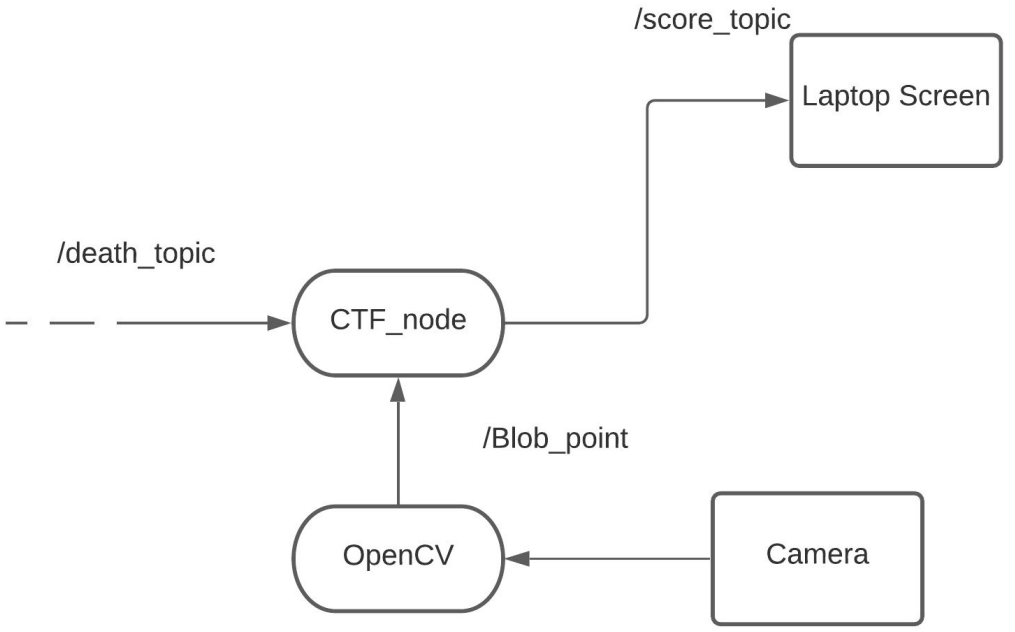
  Publish: /Blob_point

- CTF_node (Python):

  Game logic and scores count.

  Subscribe: /Blob_point

  Publish: /Score_topic



Color detection

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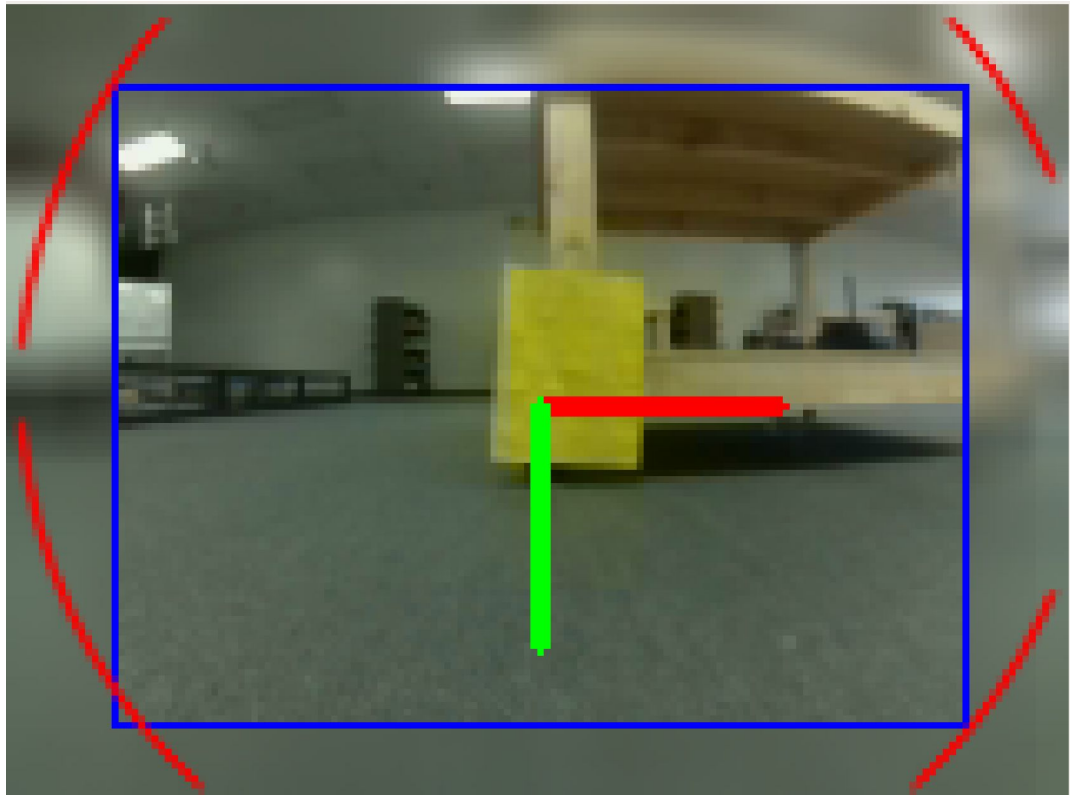
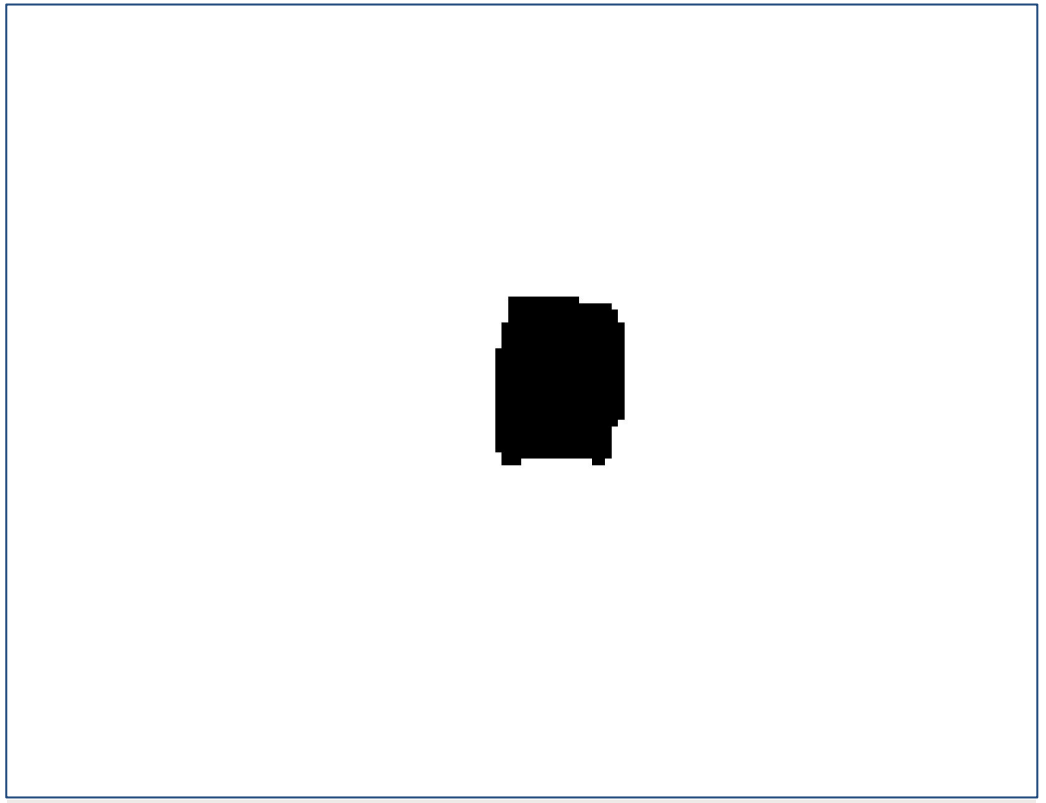
Video feed



Isolated flag



Score

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The score is shown on a computer screen:

```
---
data: "Team score is 1"
...
```

```
---
data: "Team score is 2"
...
```

Integration

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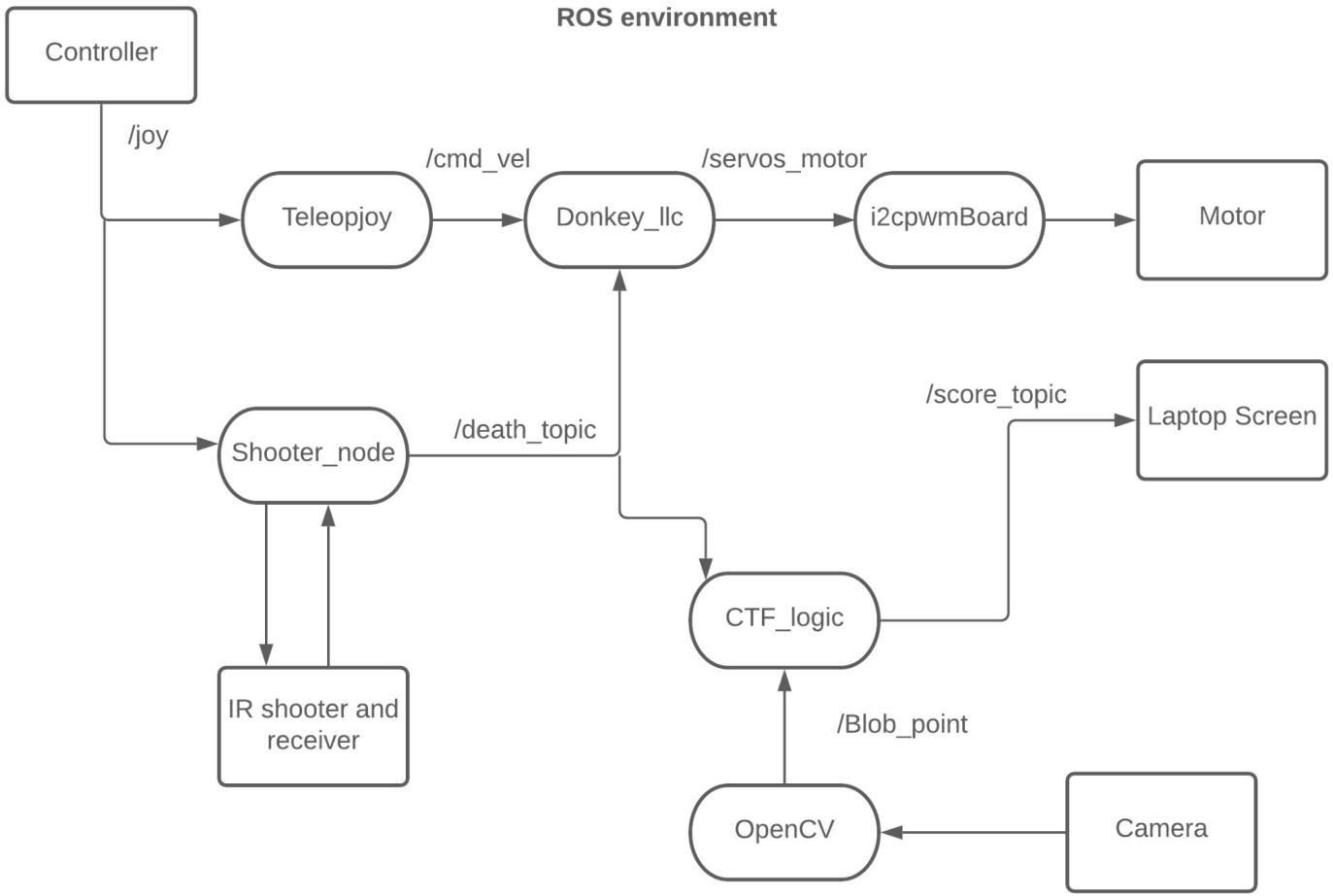

ROS Nodes Environment

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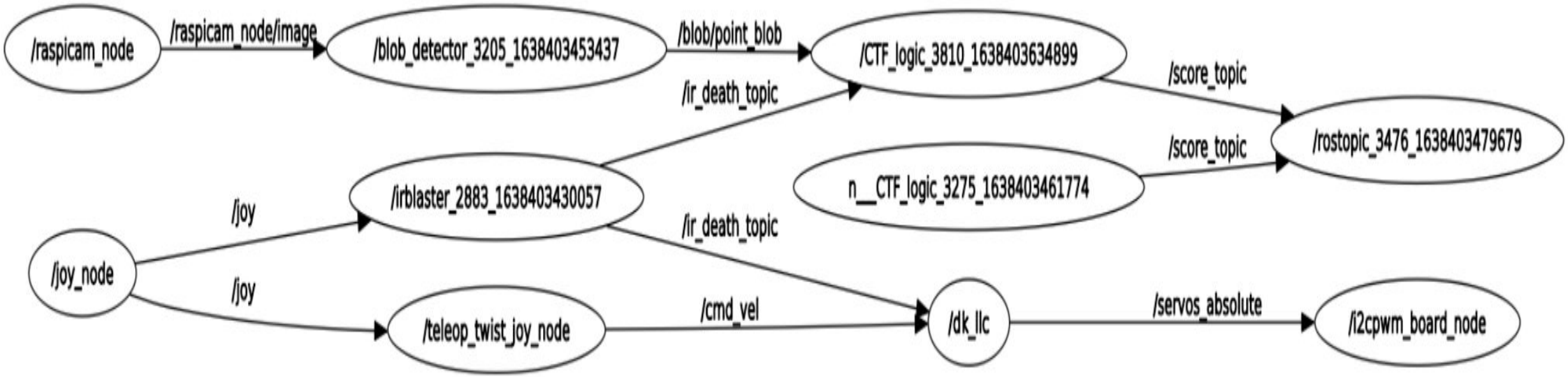

ROS Commands

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1. **Motor Control:** roslaunch donkey_llc keyboard_demo.launch
2. **Game Controller Control**: rosrun joy joy_node
3. **Game Controller Control:** rosrun teleop_twist_joy teleop_node
4. **Shooting Mechanism:** rosrun irblaster irblaster.py
5. **CTF Mechanism:** rosrun opencv find_ball.py
6. **CTF Game Logic:** rosrun CTF_logic CTF_logic.py
7. **CTF Score:** rostopic echo /score_topic
8. **CTF Camera:** rqt_image_view

ACV Project Budget

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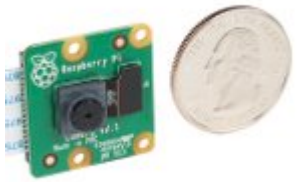
Quantity	Item	Description	Company Provider	Unit Price	Total Unit Price
8	IR Receiver Diode	Increasing DC receiving shot radius	Sparkfun	$1.95	$15.60
2	Smraza Basic Starter Kit	Breadboard, Power Supply, Jumper Wires, Resistors, LED	Amazon (Smraza)	$13.39	$26.78
2	Arducam Raspberry Pi Camera Module V2-8 Megapixel	Raspberry Pi Camera for color or QR code detection	Amazon (Arducam Store)	$39.99	$79.98
Total Cost					**$122.36**



Schedule

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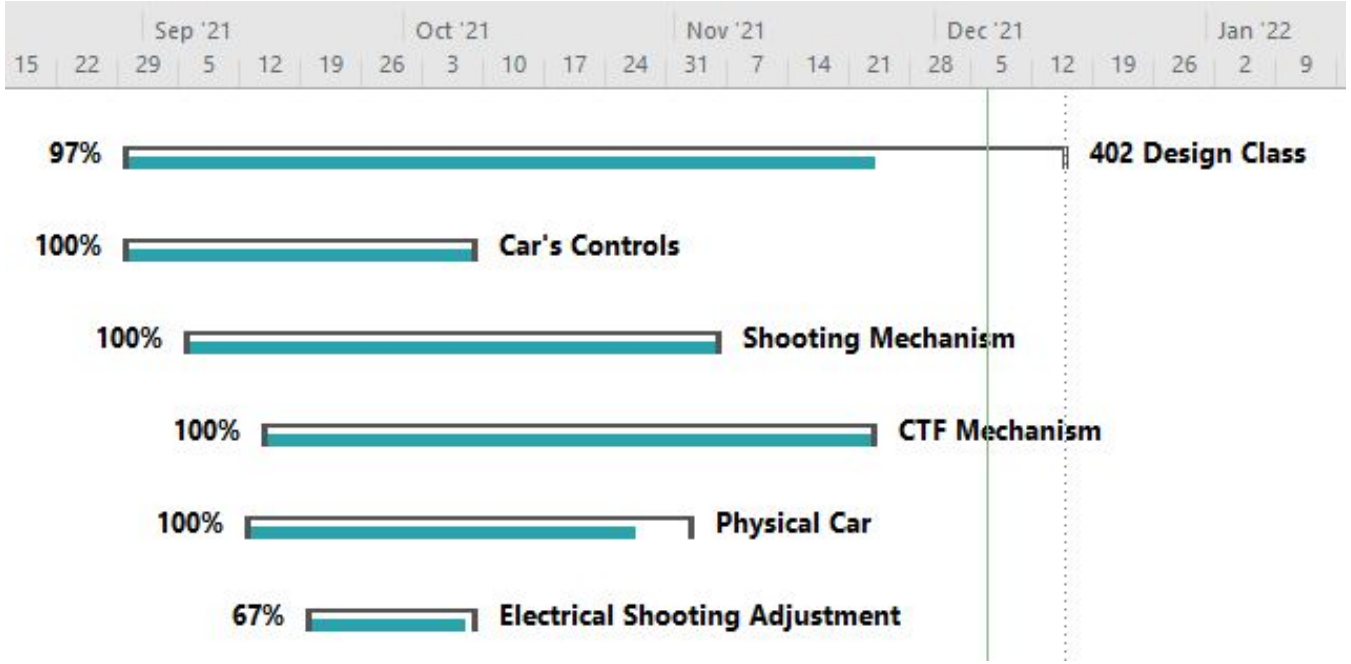

Task Name	Durat	Start	Finish	Con
402 Design Class	78 days	Mon 8/30/21	Wed 12/15/2	97%
				0%
Car's Controls	6 wks?	Mon 8/30/21	Fri 10/8/21	100%
				0%
Shooting Mechanism	45 days	Mon 9/6/21	Fri 11/5/21	100%
CTF Mechanism	50 days	Wed 9/15/21	Tue 11/23/2:	100%
				0%
Physical Car	37 days	Mon 9/13/21	Tue 11/2/21	100%
Electrical Shooting Adjustment	3 wks	Mon 9/20/21	Fri 10/8/21	67%
Buy 6 reciever diodes	1 wk	Mon 9/20/21	Fri 9/24/21	100%
Solder reciever diodes	2 wks	Fri 9/24/21	Thu 10/7/21	50%

Validation Table

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Listed Need	Validation Plan Task	Complete
The obstacles must not move when a Donkey car at full speed runs into it.	1. Drive Donkey car into workbench and verify workbench stays stationary.	X
The layout of the arena must allow for a 2ft turning radius.	2. Drive the Donkey Car in a circle and measure the diameter of the circle. Calculate the area of the circle and ensure it can fit within the SwIRL.	X
The height of the obstacles is between 1 ft and 5 ft.	3. Measure the height of the workbench and verify that it is within 1-5ft in height.	X
The car's controls must operate the car with variable speeds.	4. Verify the Donkey car can drive forward in slow speed and fast speed for 2 seconds each.	X
Controller's shooter button will be assigned to a trigger or bumper button of the controller.	5. Verify the Donkey car's IR blaster shoots using any of the following buttons on the Logitech controller: RB, RT, LB, or LT.	X
Using manual control the car must reach max speed and have the ability to turn.	6. While pressing forward turn the joystick to the left and right and verify the car turns without slowing down.	X
The chassis must contain the 3.9 in x 3.1 in x 1.1 in (Jetson Nano dimensions).	7. Visually check to see the Jetson Nano is attached to the car chassis.	X

Validation Table, cont'd

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The chassis must hold 8.8 ounces of weight.	8. Shake the Donkey car back and forth with your hands to see if the chassis deforms, if it does readjust chassis dimensions to account for the weak point.	X
Movement control, shooting, receiving, and picking up the flag must be done digitally.	9. Using the Logitech controller, drive the Donkey car and shoot another car to verify the IR blaster shooter and receiver works and that the enemy car is disabled. Using the Logitech controller, drive the Donkey car and pick up the digital flag.	X
The infrared (IR) receiving range on the Donkey car must have a circular 360 degree range.	10. Take two Donkey cars and use one to shoot the other one, position the shooting Donkey car in 8 positions separated by 45 degrees around the receiving donkey car with a minimum distance of 2 feet separating the Donkey cars.	X**
The maximum range of picking and dropping the flag is 3 ft.	11. Verify the Donkey car cannot pick up the flag at a distance of 3.5 feet from the flag pick sign.	X
A shot Donkey car must not move for 5 seconds.	12. Using one Donkey car as the target, press forward on Donkey car #1 and shoot Donkey car #1 using Donkey car #2 and while still pressing forward on Donkey car #1 verify the motor control of Donkey car #1 stops for 5 seconds.	X

**360 degree improvement delayed until post demo due to risk mitigation

Lessons Learned

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- Don’t be afraid to seek help
- As much as we hated it, planning was useful.
- Iterative design helps iron out kinks throughout.
- Waterfall planning bottlenecks progress.

Acknowledgements

- MIRC led by Dr. Ray
- Yan Yao
- Tiziano Fiorenzani
- Open Source contributors
- Rapid Prototyping Studio: Chase & Ryan
- Dr. Cope, for enabling the team

SwIRL CTF Arena MAP

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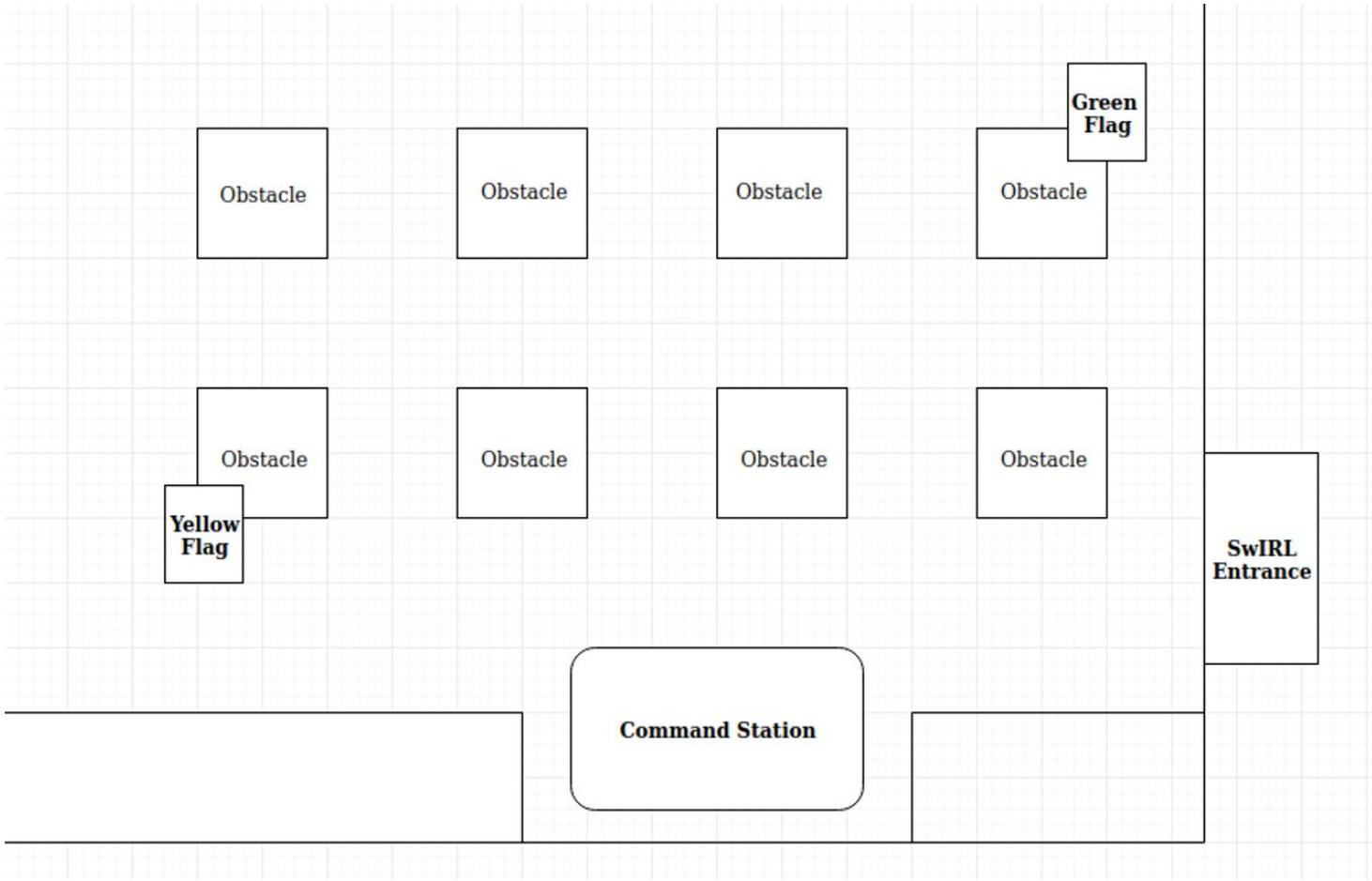

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Demo

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Question?