



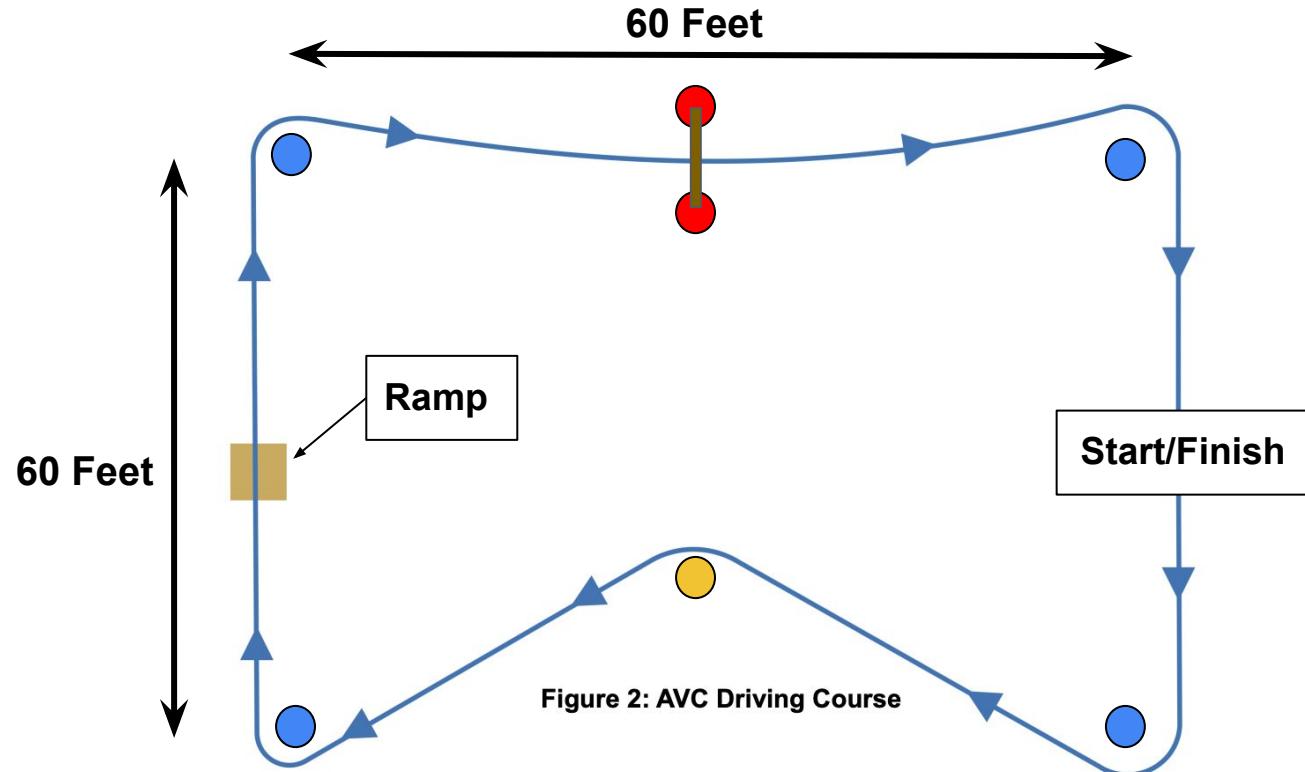
# Vision-Based Autonomous Driving Using a Neural Network

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**Faculty Mentor:** Dr. Lin Zhang



# 2023 National Robotics Challenge



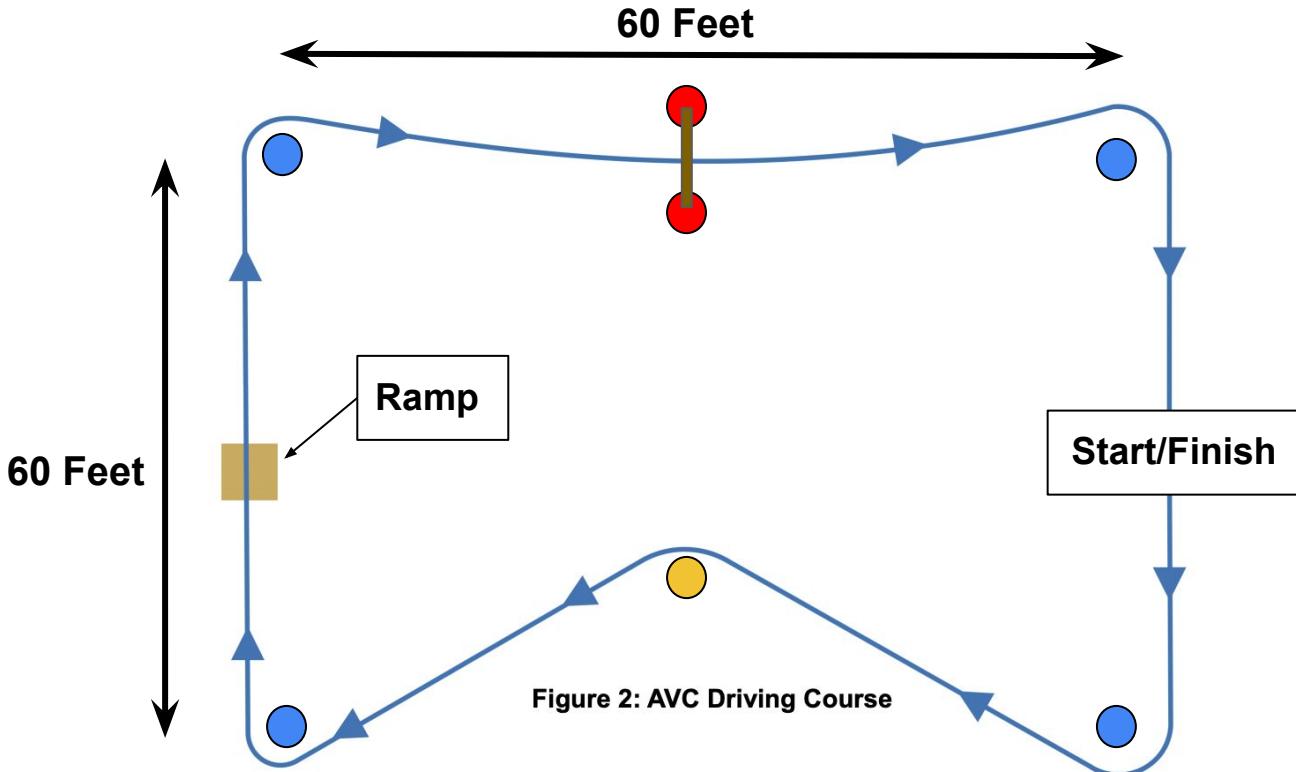
# 2023 National Robotics Challenge

## Points Awarded for:

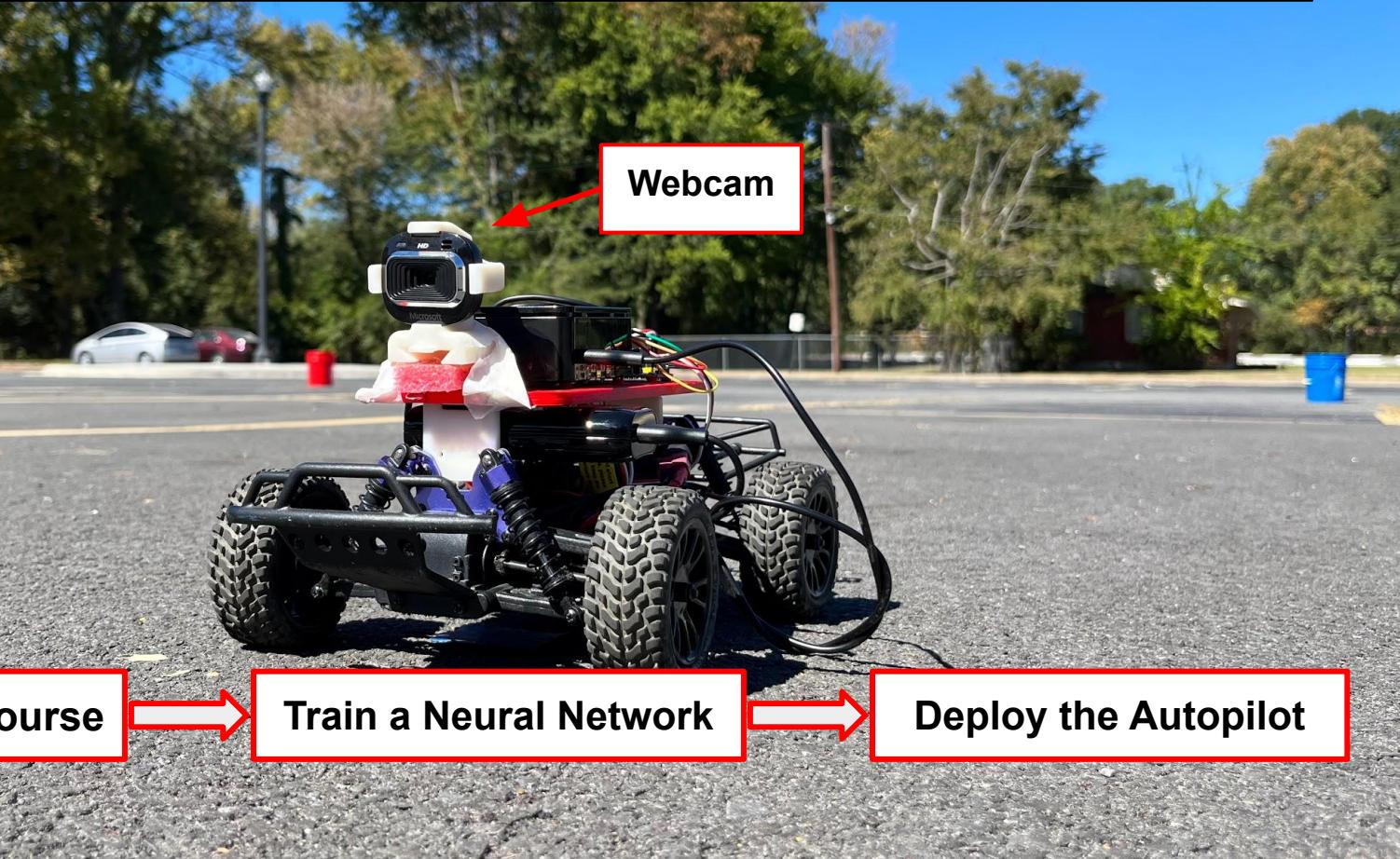
- Under 5 minutes
- Drive around all five corners
- Clear the ramp
- Pass through the arch

## Requirements:

- 24" x 24" x 24"
- No wireless connection



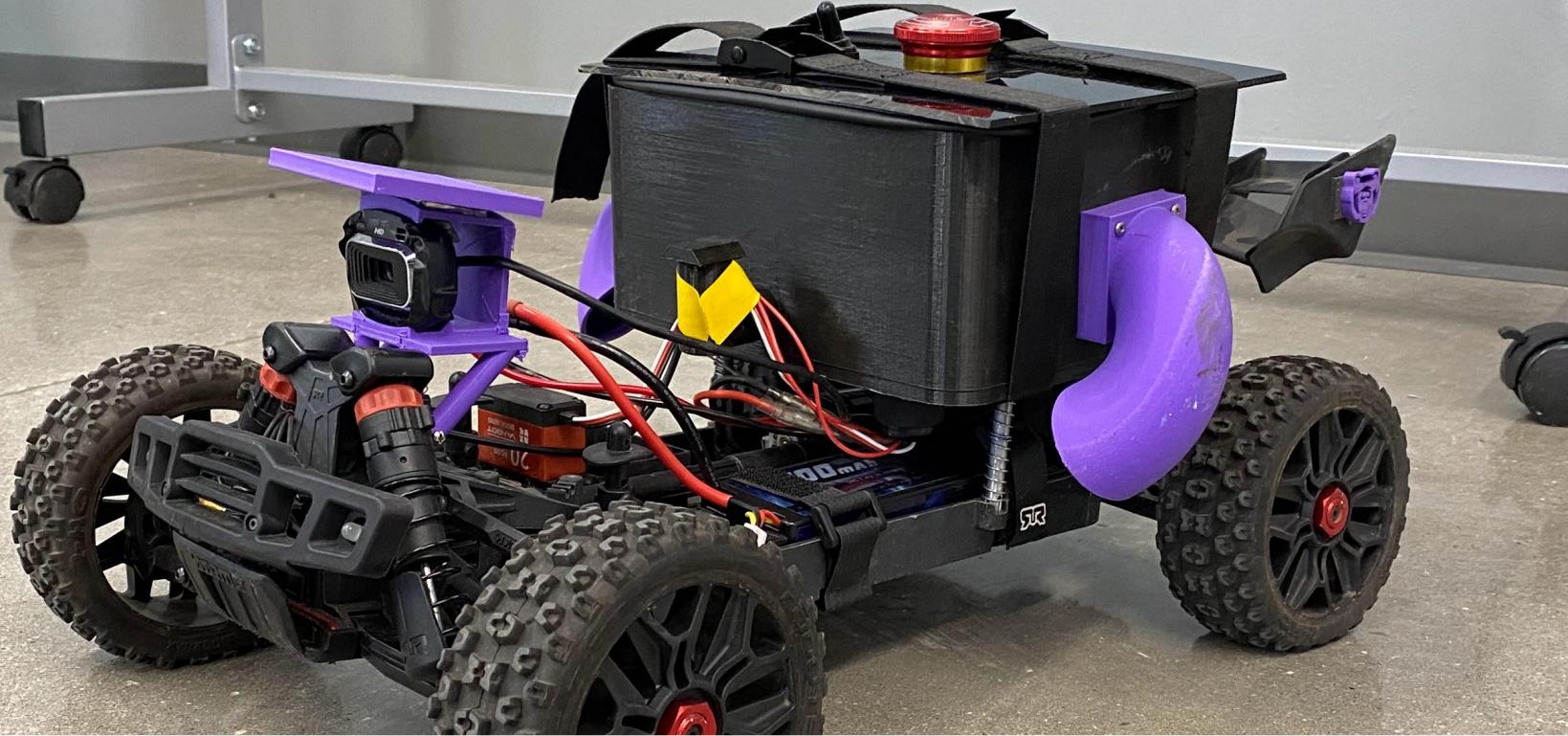
# 2022 NRC Gold Medal Winner (UCA Trojan Donkey Team)



Collect Data on Course

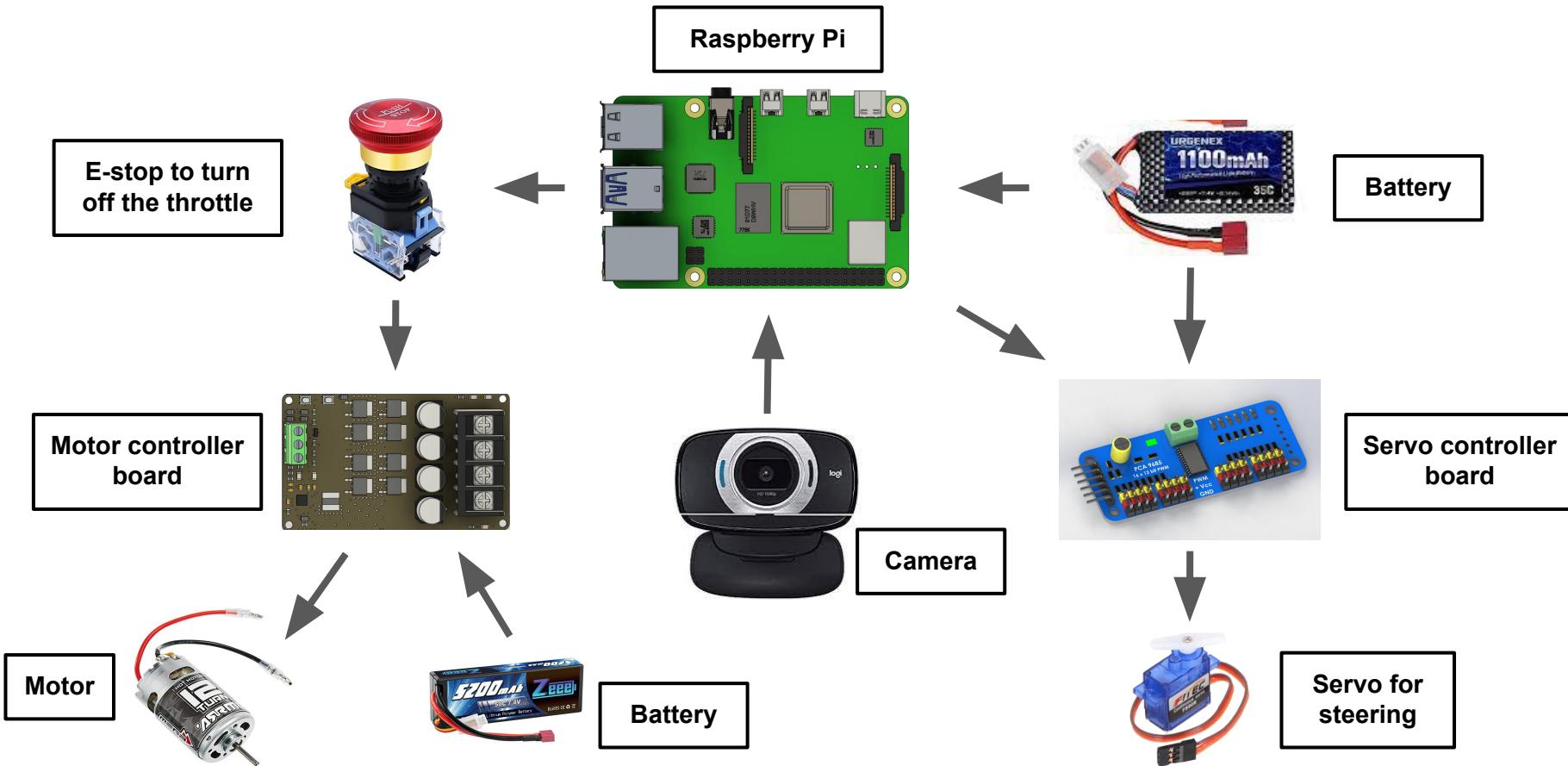
Train a Neural Network

Deploy the Autopilot



# 1. Collecting Data

# Hardware



# Hardware Iterations



Camera  
with Mount



3D Printed  
Chassis



More Durable  
Chassis

Air Ventilation

# Hardware Safety Features

ANSI/ITSDF B56.5-2019

**5.2.2: The physical environment, including temperature, humidity, ambient weather (e.g., exposed dock), air quality (e.g., explosive particles, and/or gaseous constituents) shall be a part of the vehicle design criteria.**

- Waterproofed the container housing the electronics.
- Sealed battery connections.
- Stored LiPo batteries in a fireproof container.

# Hardware Safety Features (cont)

ANSI/ITSDF B56.5-2019

**8.9.1 Prior to initiation of vehicle movement or remote reactivation from a sleep or inactive condition, a warning device (on or off the vehicle) shall be activated, to be either audible, visual, or a combination thereof, indicating the imminent movement of the vehicle under automatic control. The warning light(s), such as strobe or flashing shall be readily visible.**

**8.95 An indication should be provided for all vehicles capable of automatic operation to identify low battery condition when automatic routing to battery charging is not provided.**

- Headlights on the car turn on when the autopilot is active.
- Lipo battery voltage indicators to identify low batteries.

# Hardware Safety Features (cont)

ANSI/ITSDF B56.5-2019

**8.10.2 Mandatory emergency control functions and devices shall include the following:**

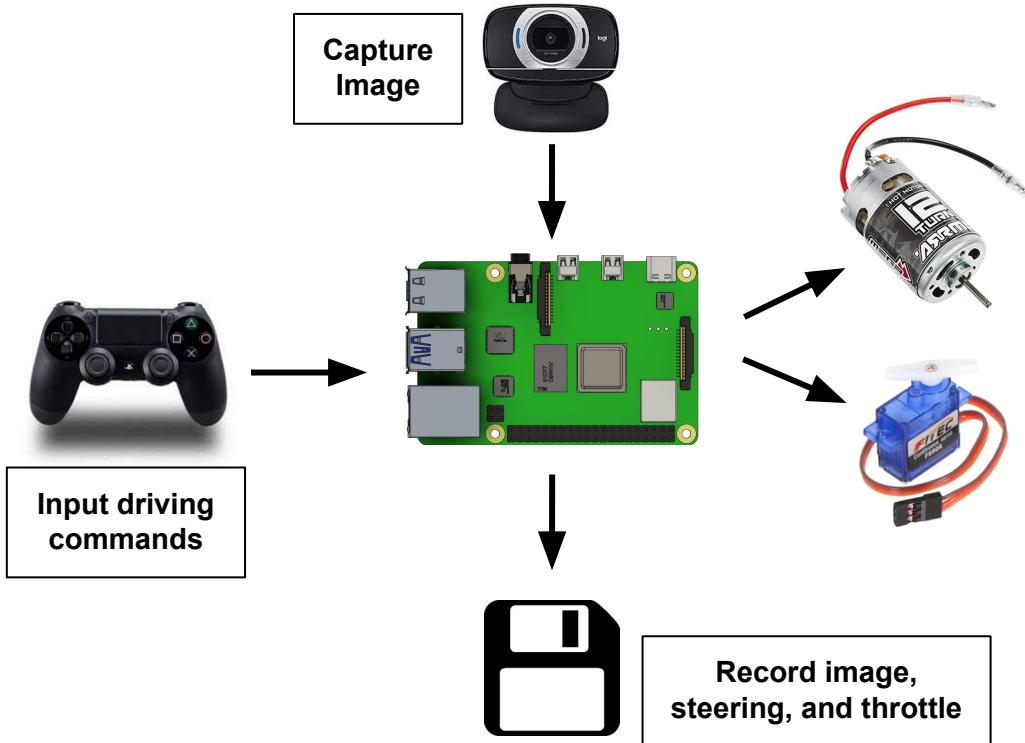
- (a) Emergency stop switches (e.g., red mushroom), located on or off the vehicle and accessible to personnel.
- (b) Detection of loss of speed control.
- (c) ...

- Large emergency stop button on the top of the car cuts power to the motor.
- Car stops automatically during data collection if connection to the controller is lost.

# Data Collection Program

## Current Version

- Car is controlled using a PS4 controller.
- Adjustable video settings
- Adjustable steering trim and throttle limit
- Stores images as JPGs.
- Can create new datasets or append an existing one.



# Image Labeling During Collection

Image 150



Image 151



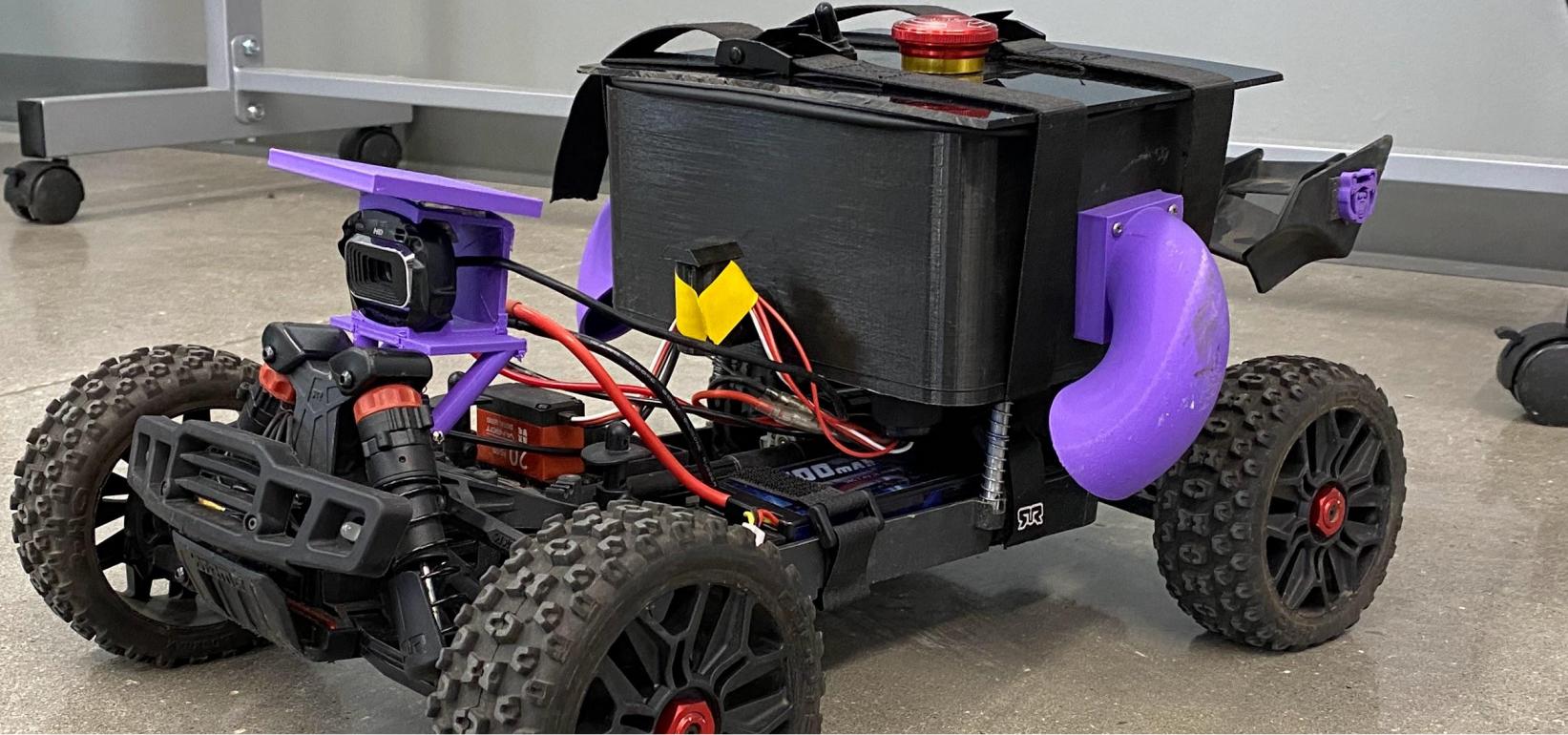
Image 152



Image Label:  
Steering = -0.44  
Throttle = -1

Image Label:  
Steering = -0.03  
Throttle = -1

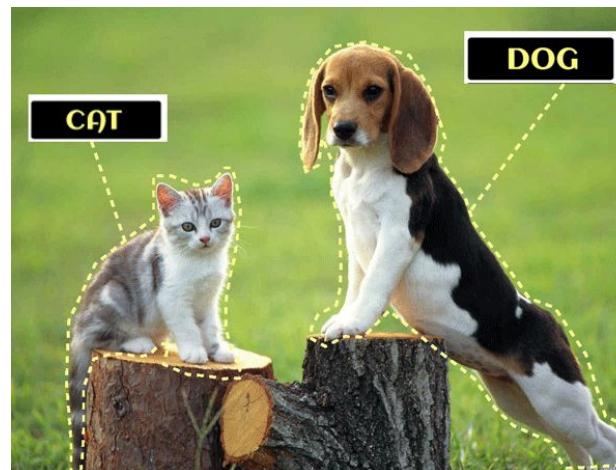
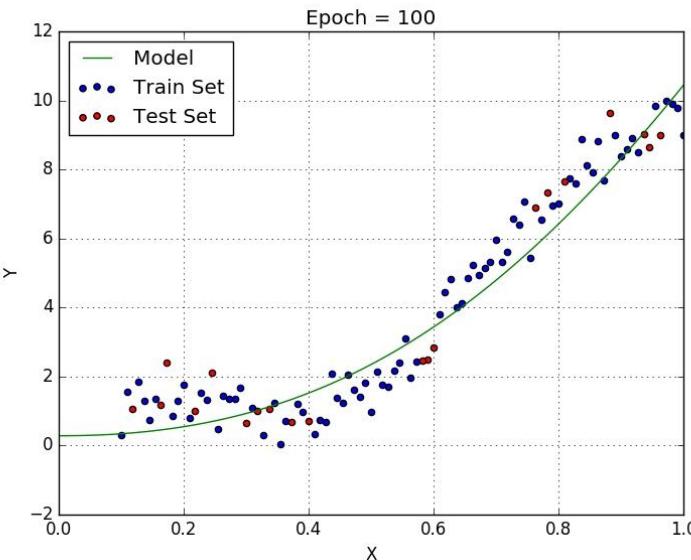
Image Label:  
Steering = 0.28  
Throttle = -1



## 2. Train a Neural Network

# What is a Neural Network?

- Method of pattern recognition in data
- System of trainable parameters



# What is a Neural Network?

$$\begin{bmatrix} x_1 & x_2 & x_3 \\ x_4 & x_5 & x_6 \end{bmatrix} \begin{bmatrix} W_1 \\ W_2 \\ W_3 \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \end{bmatrix} = \begin{bmatrix} p_1 \\ p_2 \end{bmatrix}$$

Image Data (Numeric Pixel Values)

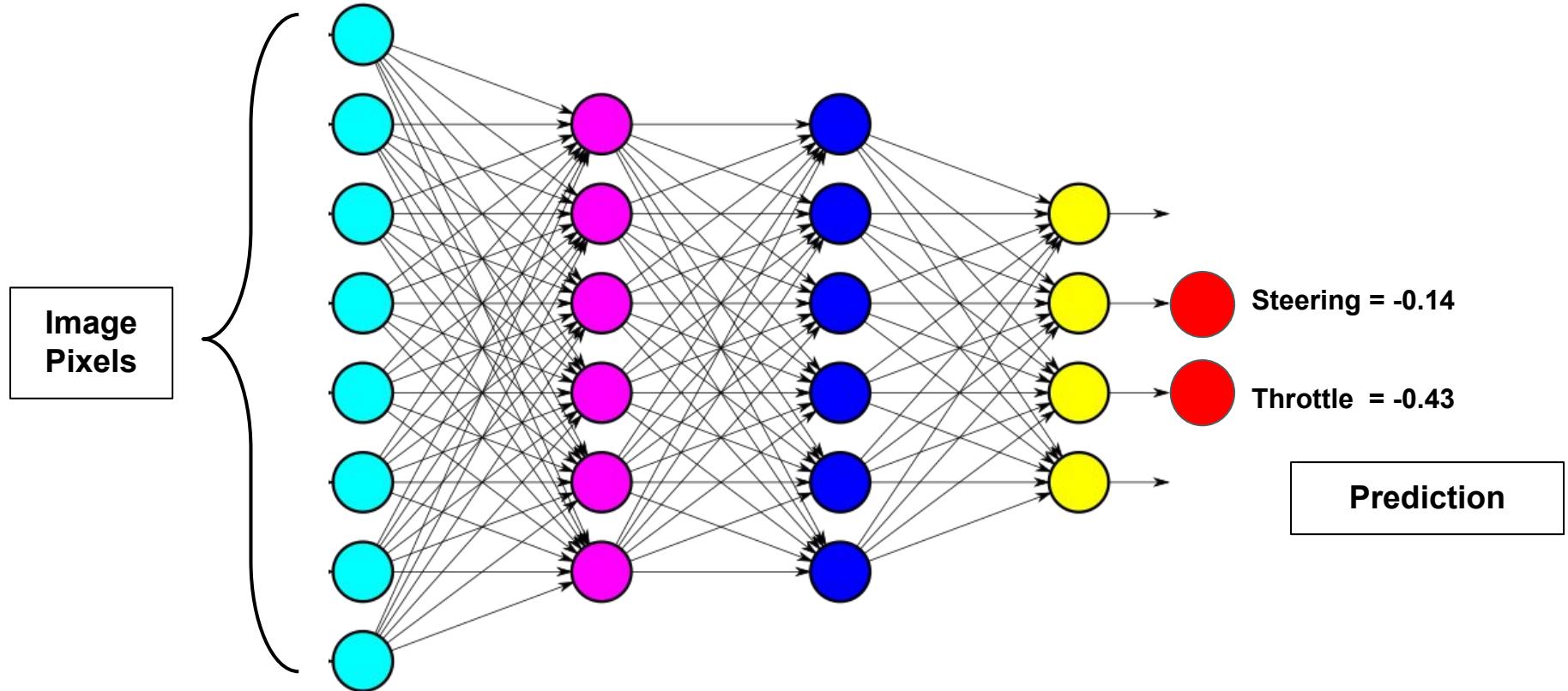
Weights

Biases

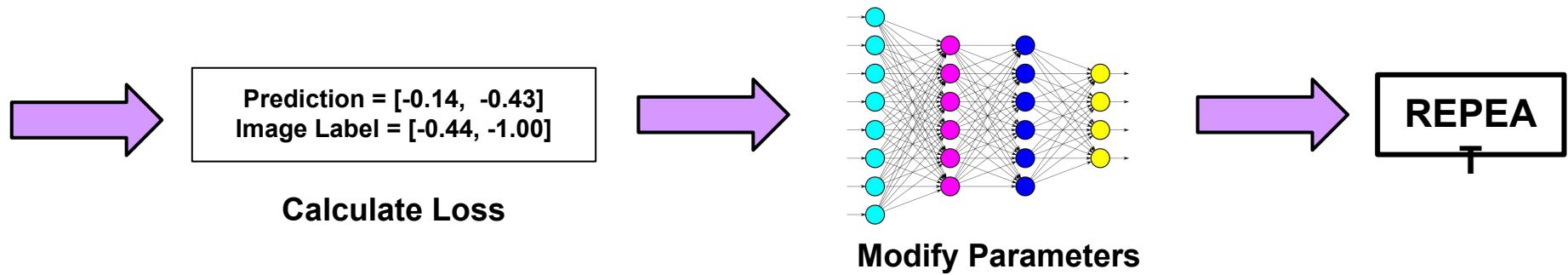
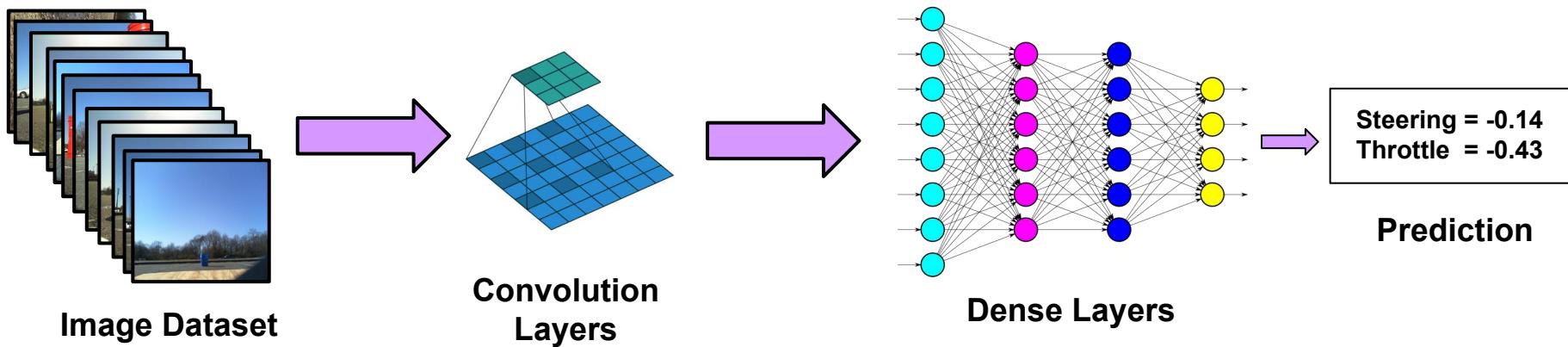
Prediction

Optimize for best predictions

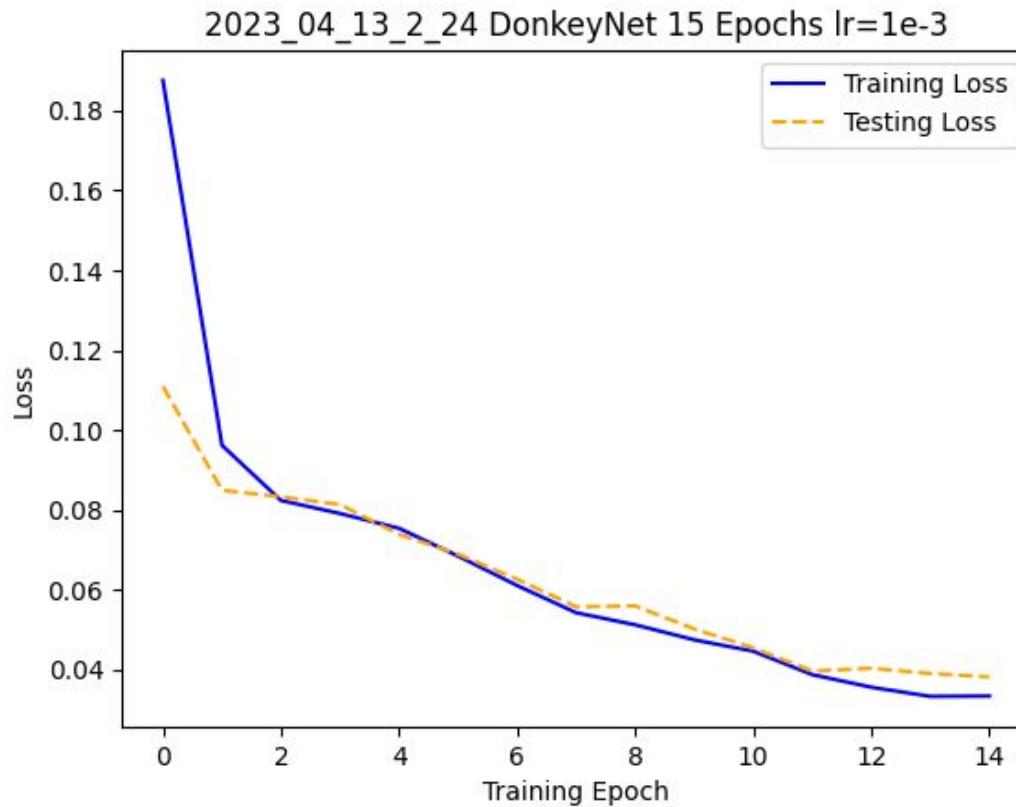
# What is a Neural Network?

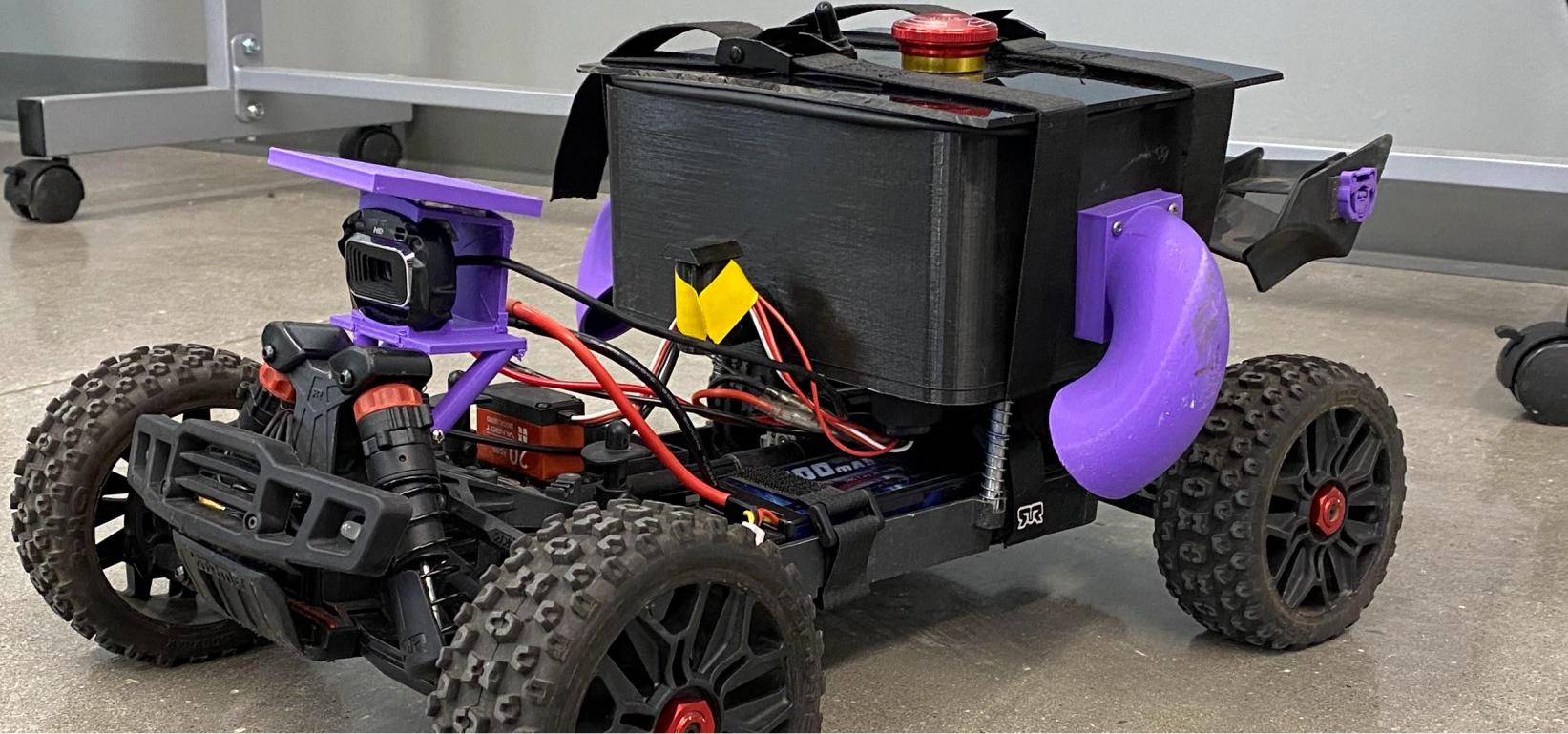


# Convolutional Neural Network Overview



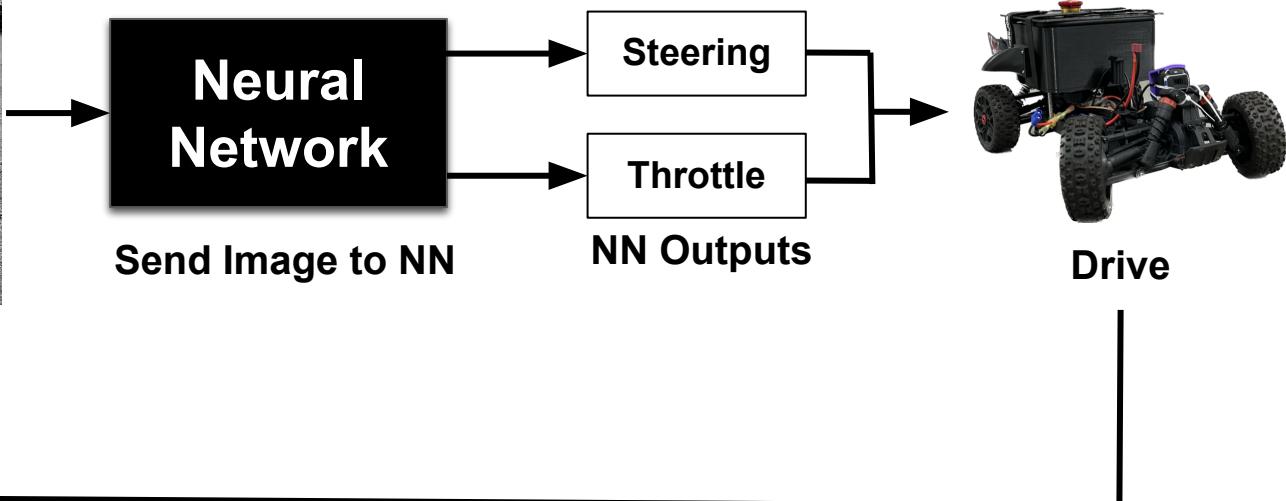
# Neural Network Goal





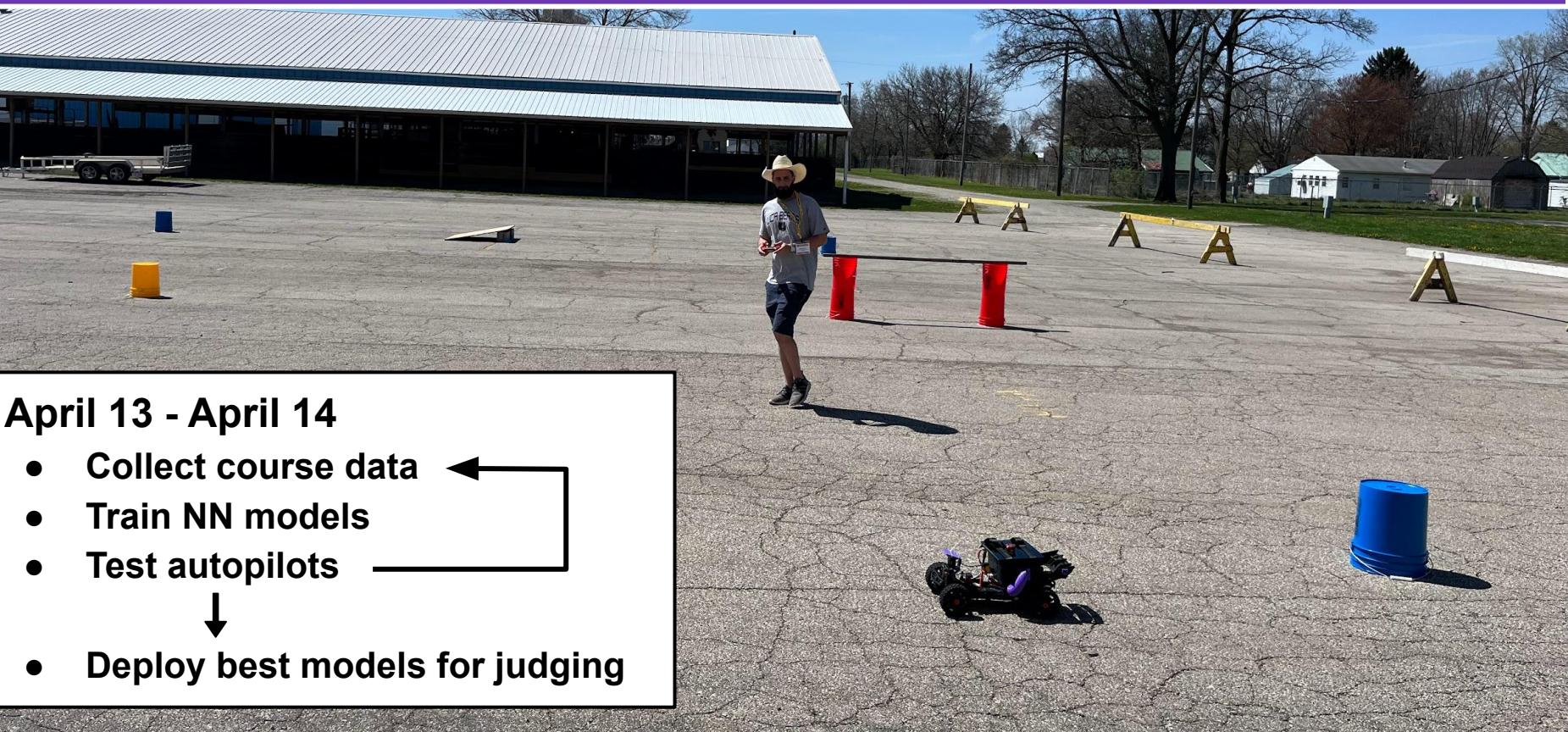
### 3. Deploy the Autopilot

# Autopilot Loop



Continuous Loop

# 2023 National Robotics Challenge



**April 13 - April 14**

- Collect course data ←
- Train NN models
- Test autopilots ↓
- Deploy best models for judging

# “Best” of Three Attempts

## Points Earned:

- Passed 1st bucket
- Passed 4th bucket

## Points Lost:

- Yellow bucket (2nd)
- Ramp
- Under the arch
- Final bucket
- Finish Line



# Success at ASGC

## Points Earned:

- Passed all blue buckets
- Finish line
- Ramp
- Under the arch

## Points Lost:

- Yellow bucket (2nd)



# Conclusions

## Results

- Developed an approachable autonomous vehicle platform
- Built a stable hardware model
- Trained successful autopilots
- All code is open source on GitHub for future Senior Design teams



# Conclusions

## Main Problem

- Poor AI performance in sunny weather
- Attempts to Solve
  - Add sunglasses in front of camera
  - Shade the camera from above
  - Increase the amount of data used to train
  - Stereo depth imaging

## Future Work

- Incorporating a depth camera
- Testing new NN architectures
- Training models in a simulation
- Implement reinforcement learning

