Self-Driving Vehicular Project

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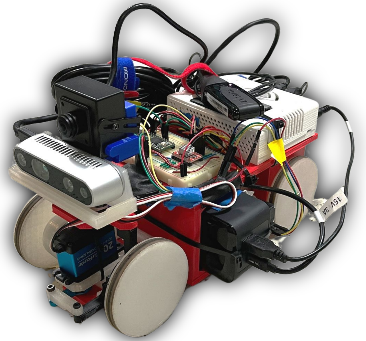
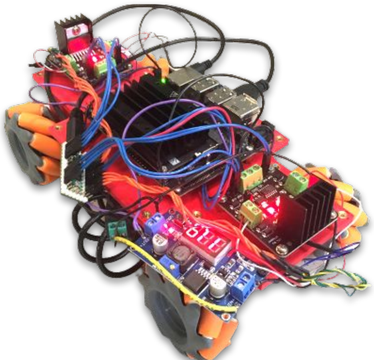
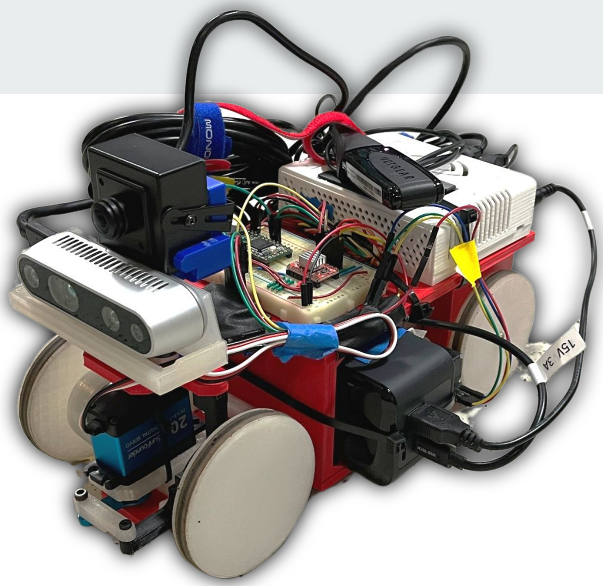


Advisors: Ivan Seskar and Jennifer Shane

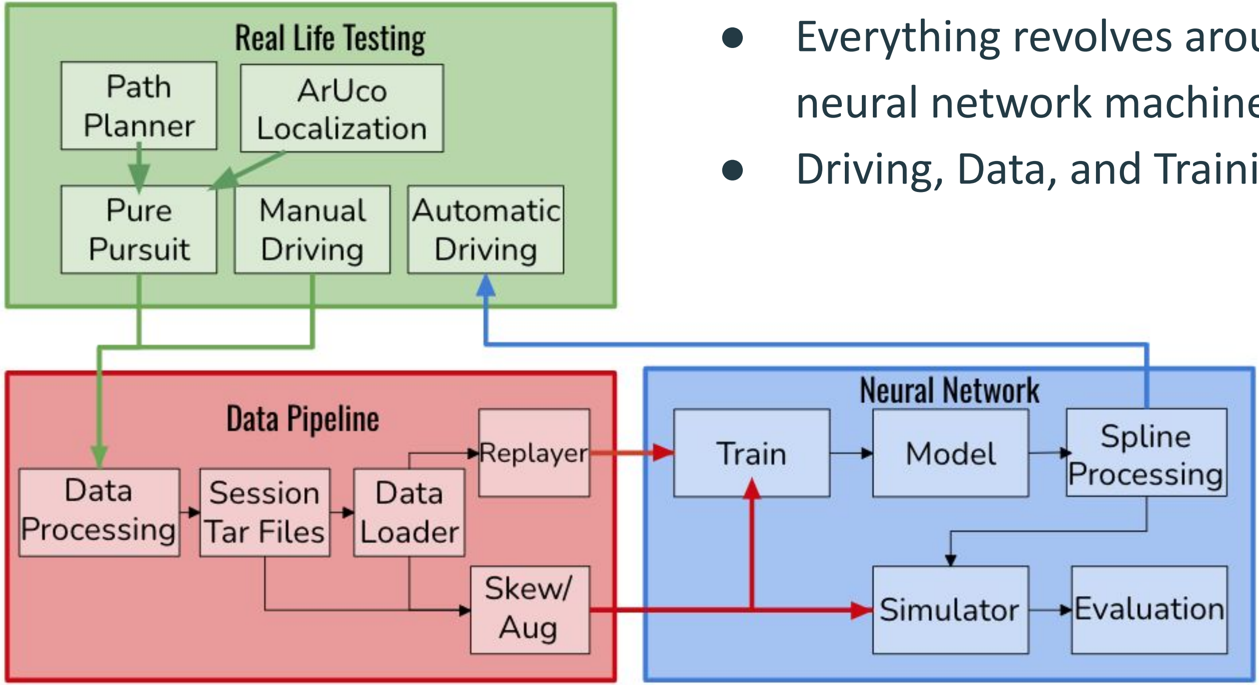


Project Overview

- RASCAL (Robotic Autonomous Scale Car for Adaptive Learning)
- **Goal**
  - Assemble and document the creation of a 3D printed self driving car
  - reacts to a city environment



System Architecture

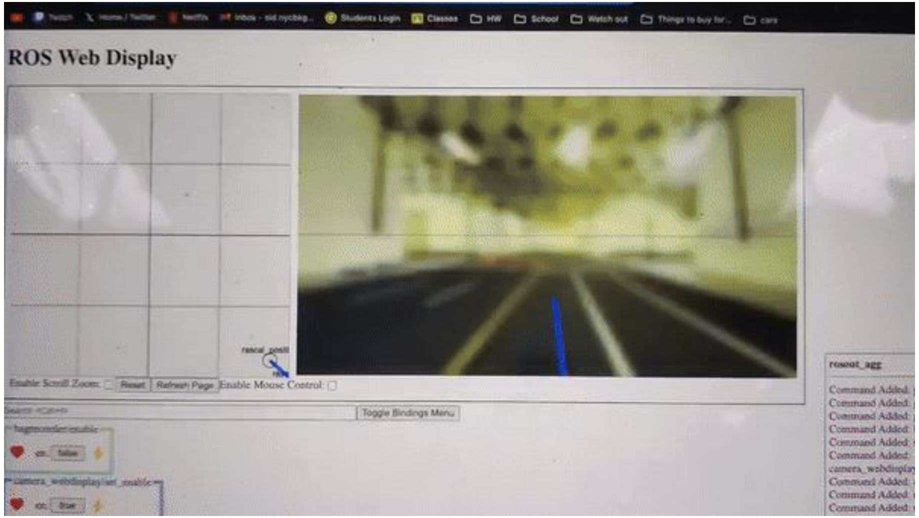


- Everything revolves around the neural network machine learning
- Driving, Data, and Training

Data Collection and Processing

Training a neural network requires a lot of data to learn from

- Goal: Create a streamlined process for getting a lot of data.
- Recorded raw images and pose in ROS bags
- Converted to videos and CSV labels



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Command Added:
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camera_webdisplay
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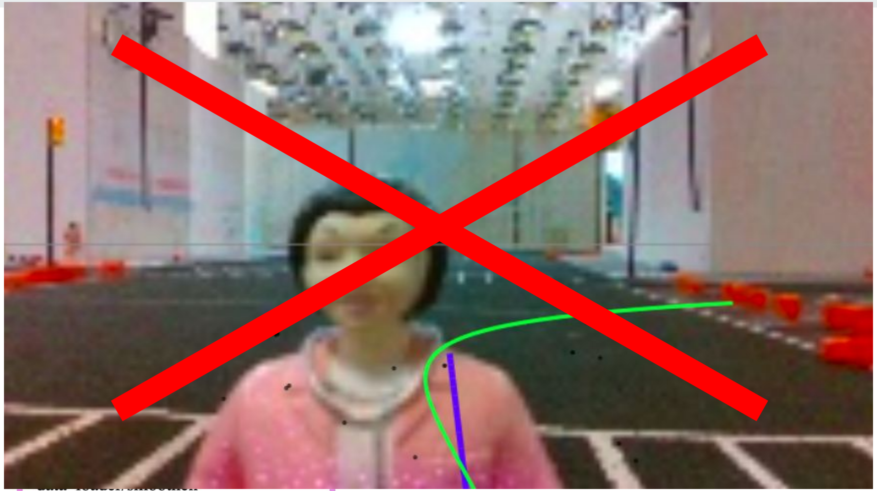
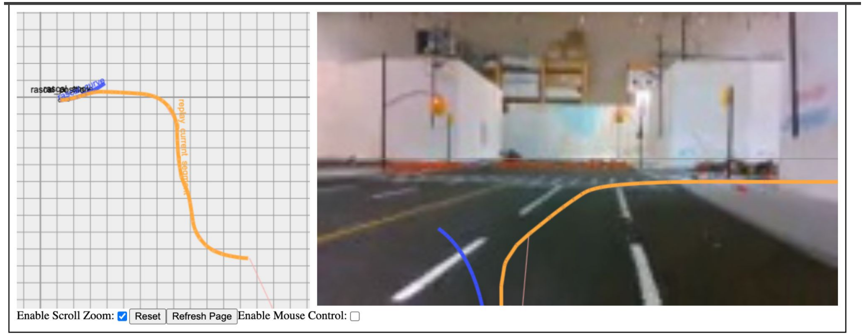
Replay Editing

Watching and editing data in the simulator web display.

- Goal: View and edit data to remove bad data
- Smoothen data for training
- Ensure high quality data collection





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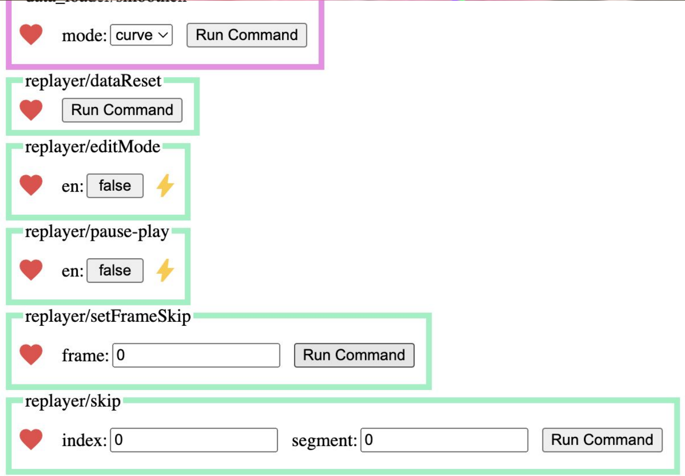


mode: curve Run Command

replayer/dataReset

Run Command

replayer/editMode

en: false

replayer/pause-play

en: false

replayer/setFrameSkip

frame: 0 Run Command

replayer/skip

index: 0 segment: 0 Run Command

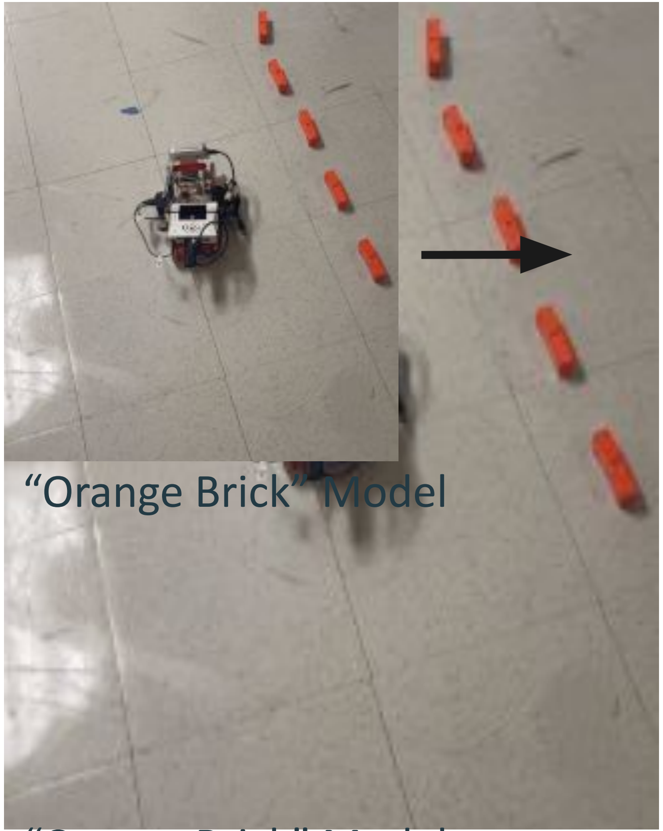
CNN Model Progression

“Yellow Thingy” Model

“Yellow Thingy” Model

CNN Model Progression

“Yellow Thingy” Model

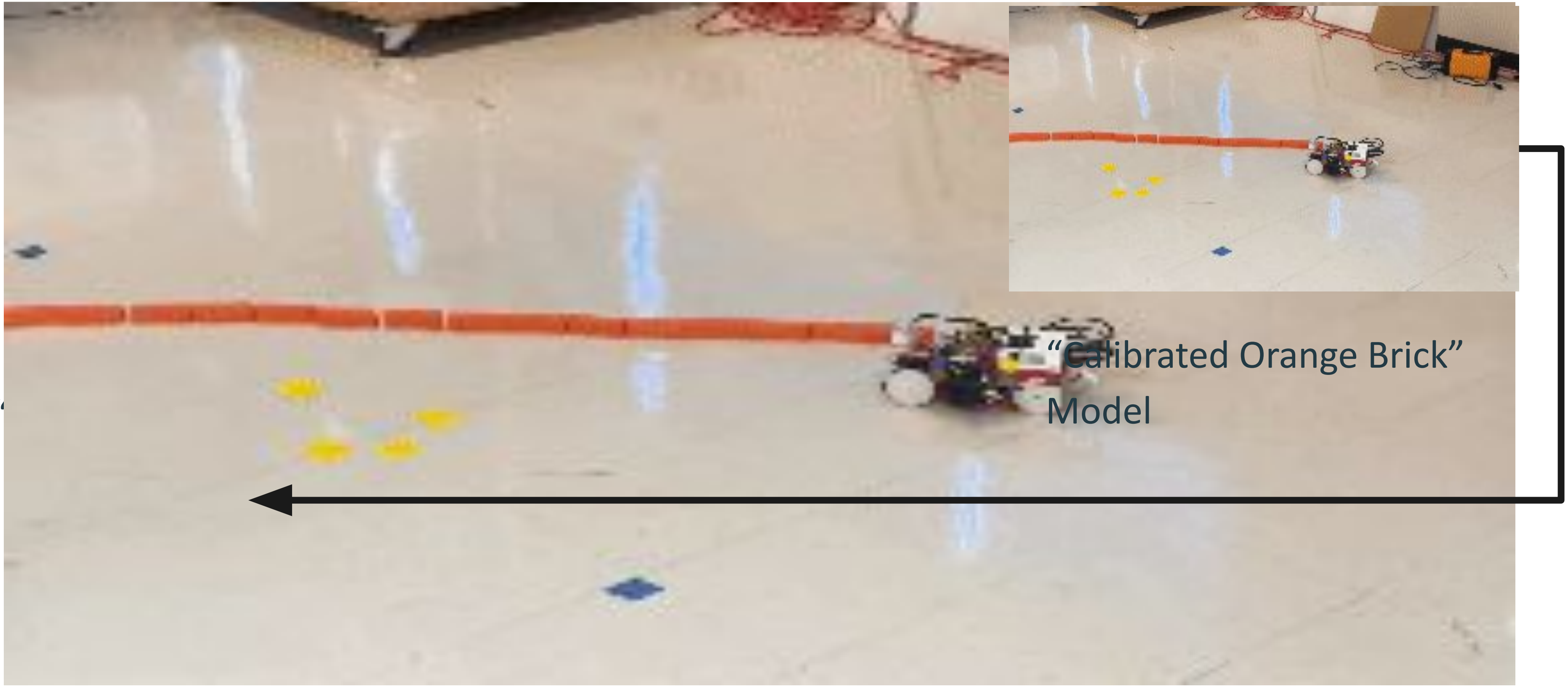


“Orange Brick” Model

“Orange Brick” Model

CNN Model Progression

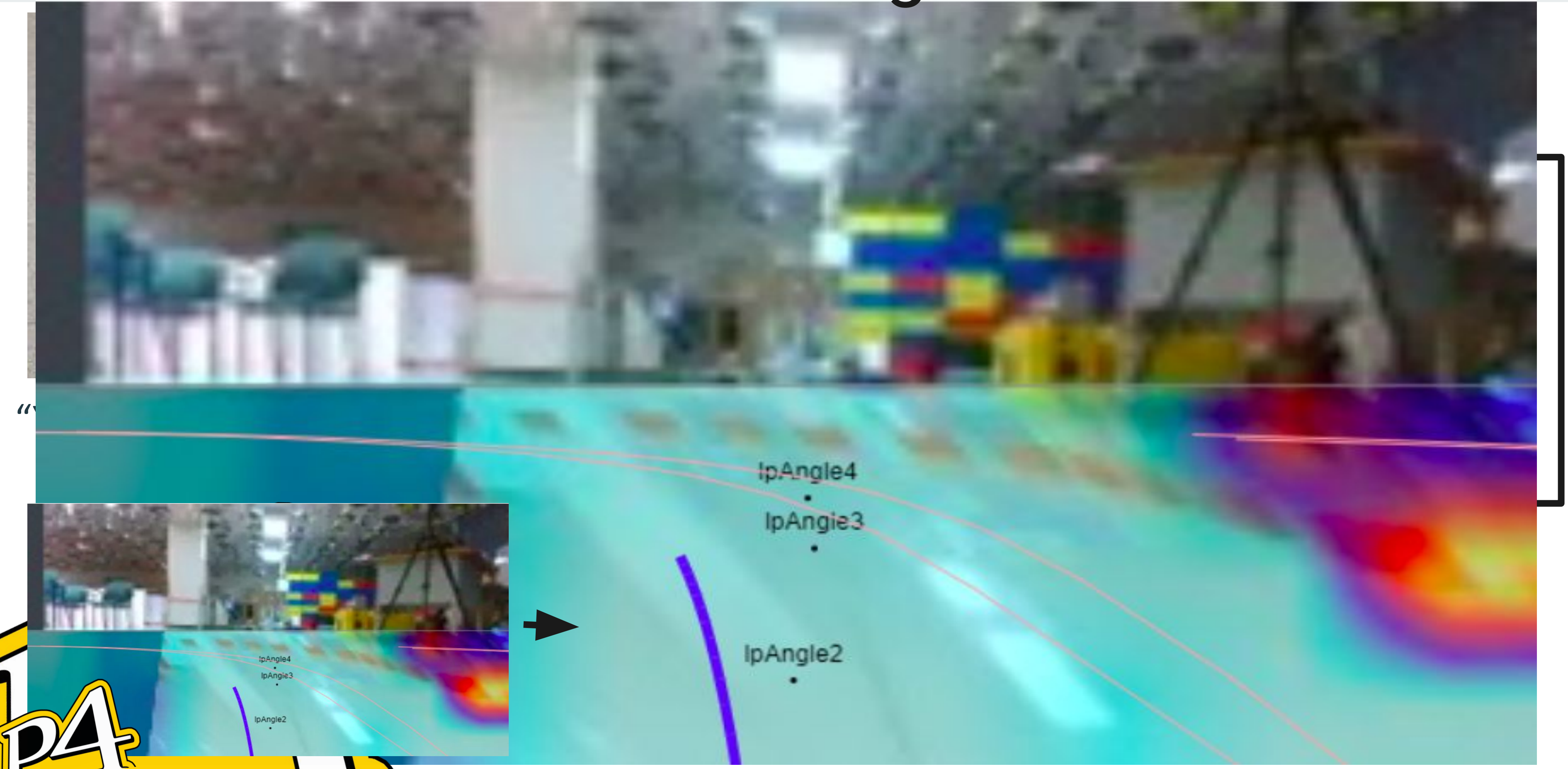
“



“Calibrated Orange Brick” Model

“Calibrated Orange Brick” Model

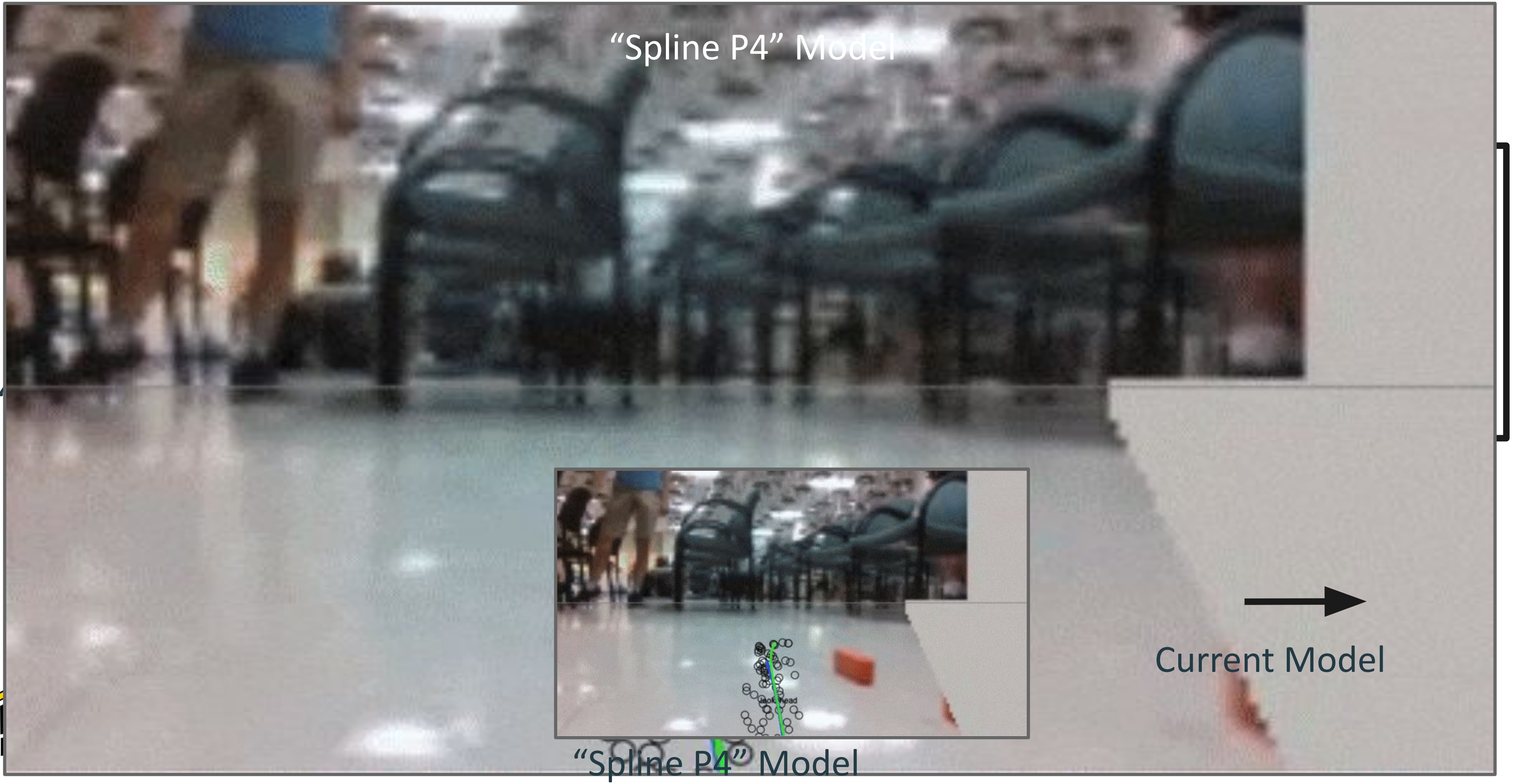
CNN Model Progression



“P4” Model

“P4” Model

CNN Model Progression



“Spline P4” Model

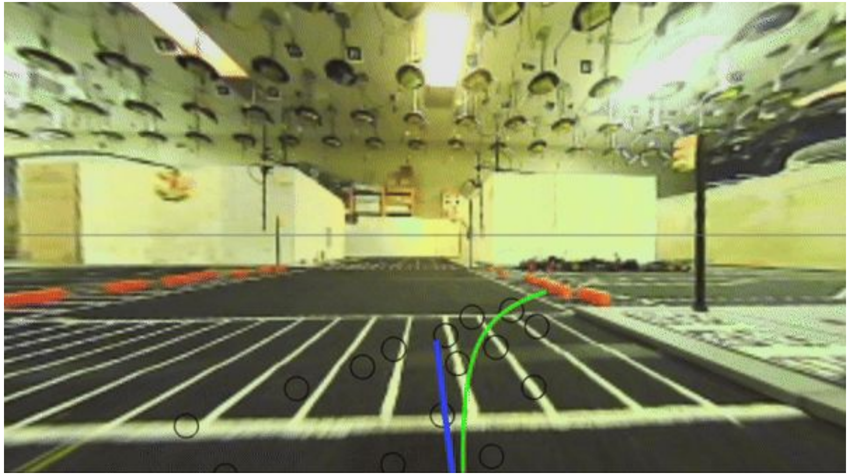
“Spline P4” Model

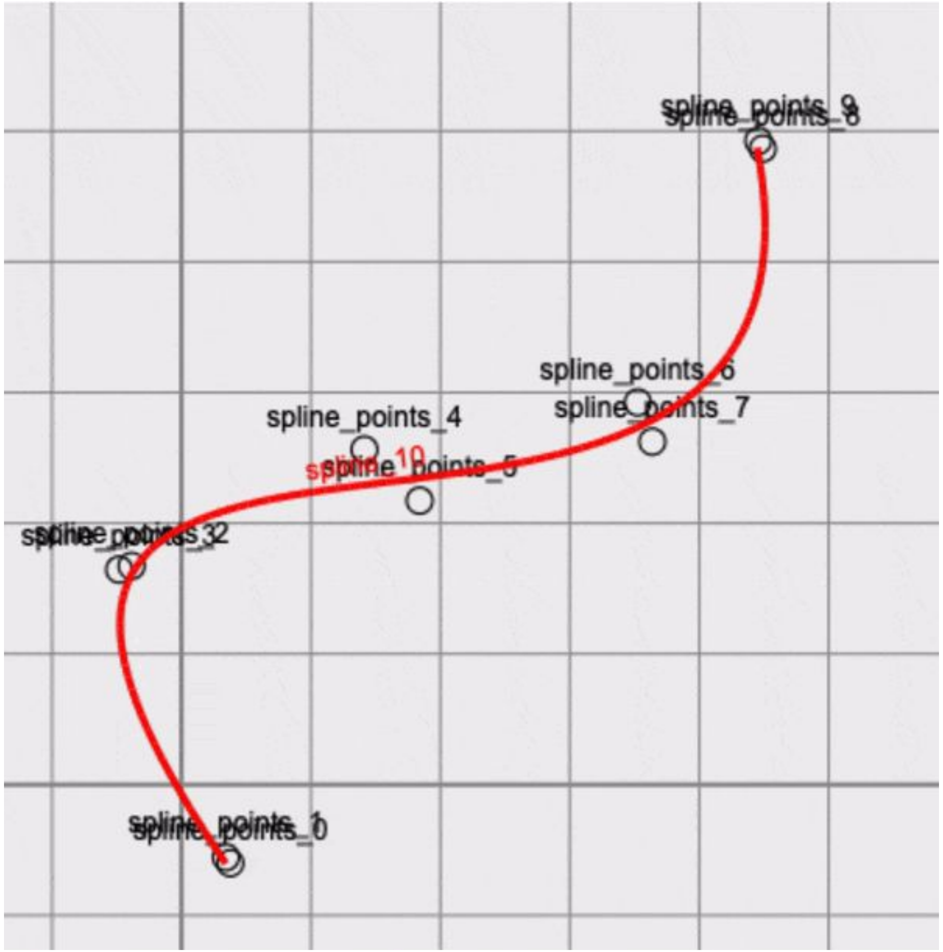
Current Model

Current Model

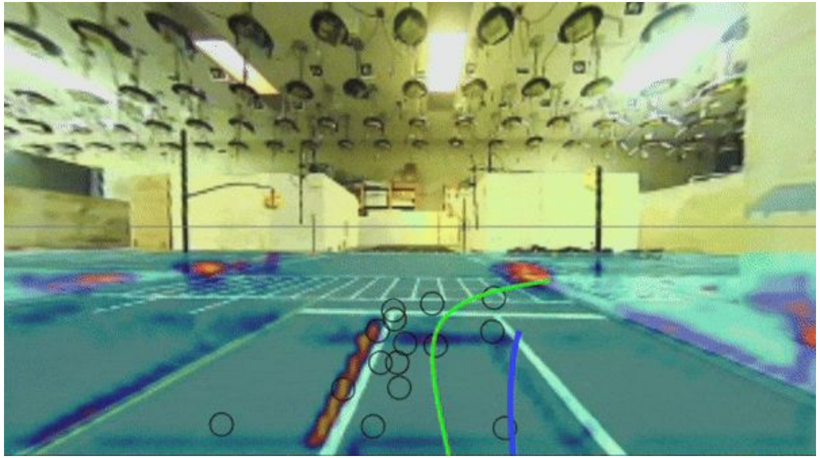
Trained on city data

“P4 Fish Spline” Model





Understanding the Model



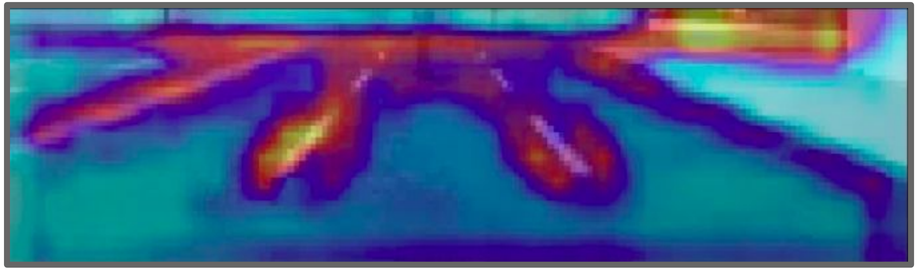
Gradient Class Activation Map Heatmap

- Allows us to better understand what our model is learning

Model Testing

- Troubleshoot issues with the model

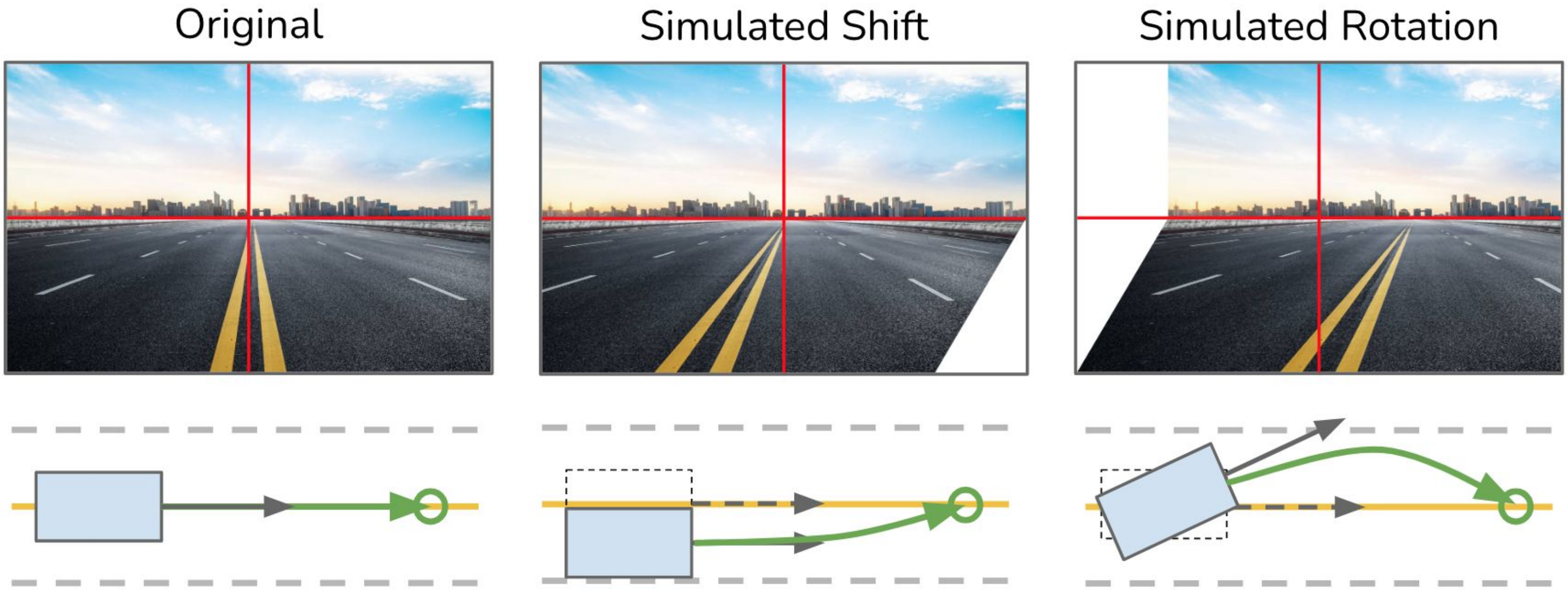
Normalized Image



Grad-CAM Heatmap

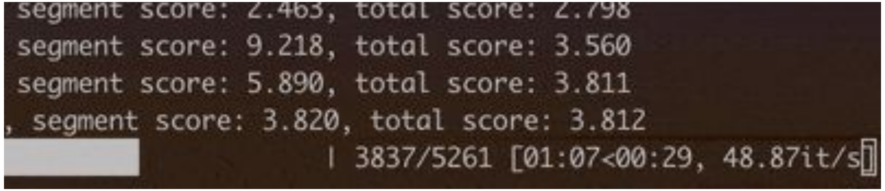
Augmentation

- Goal: get more varied data
- More examples of different scenarios will teach the model what to do in that situation



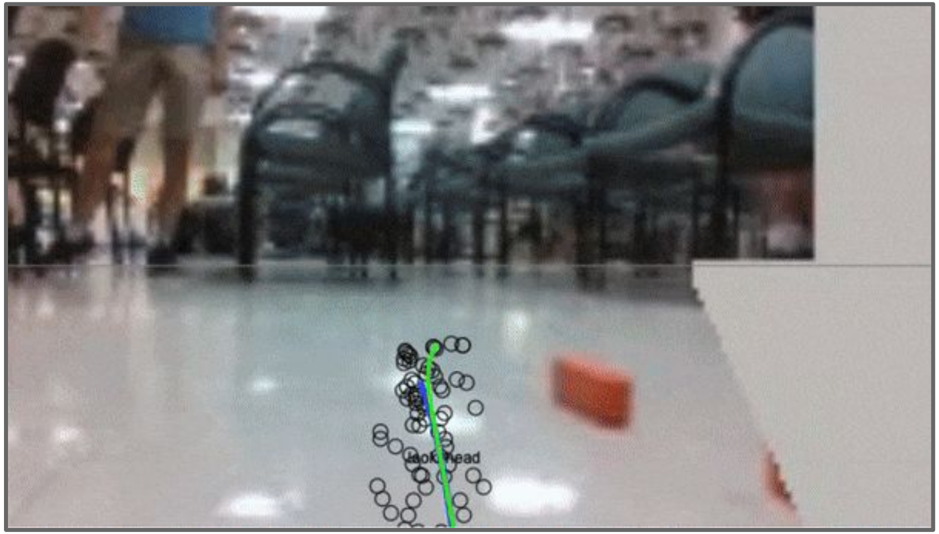
Simulation + Evaluation

- Goal: Quantify how good our model is
- Simulate the environment by skewing images from our recordings
- Drive in the simulated environment and record number of times crashed



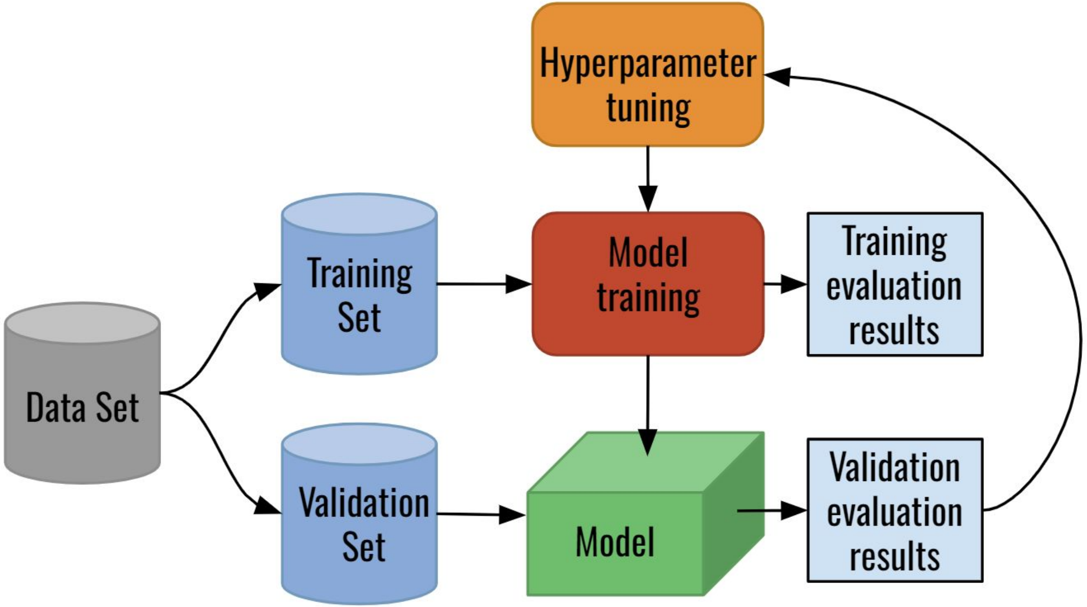
```
segment score: 2.463, total score: 2.798
segment score: 9.218, total score: 3.560
segment score: 5.890, total score: 3.811
, segment score: 3.820, total score: 3.812
                    | 3837/5261 [01:07<00:29, 48.87it/s]
```

Simulated Camera and spline model

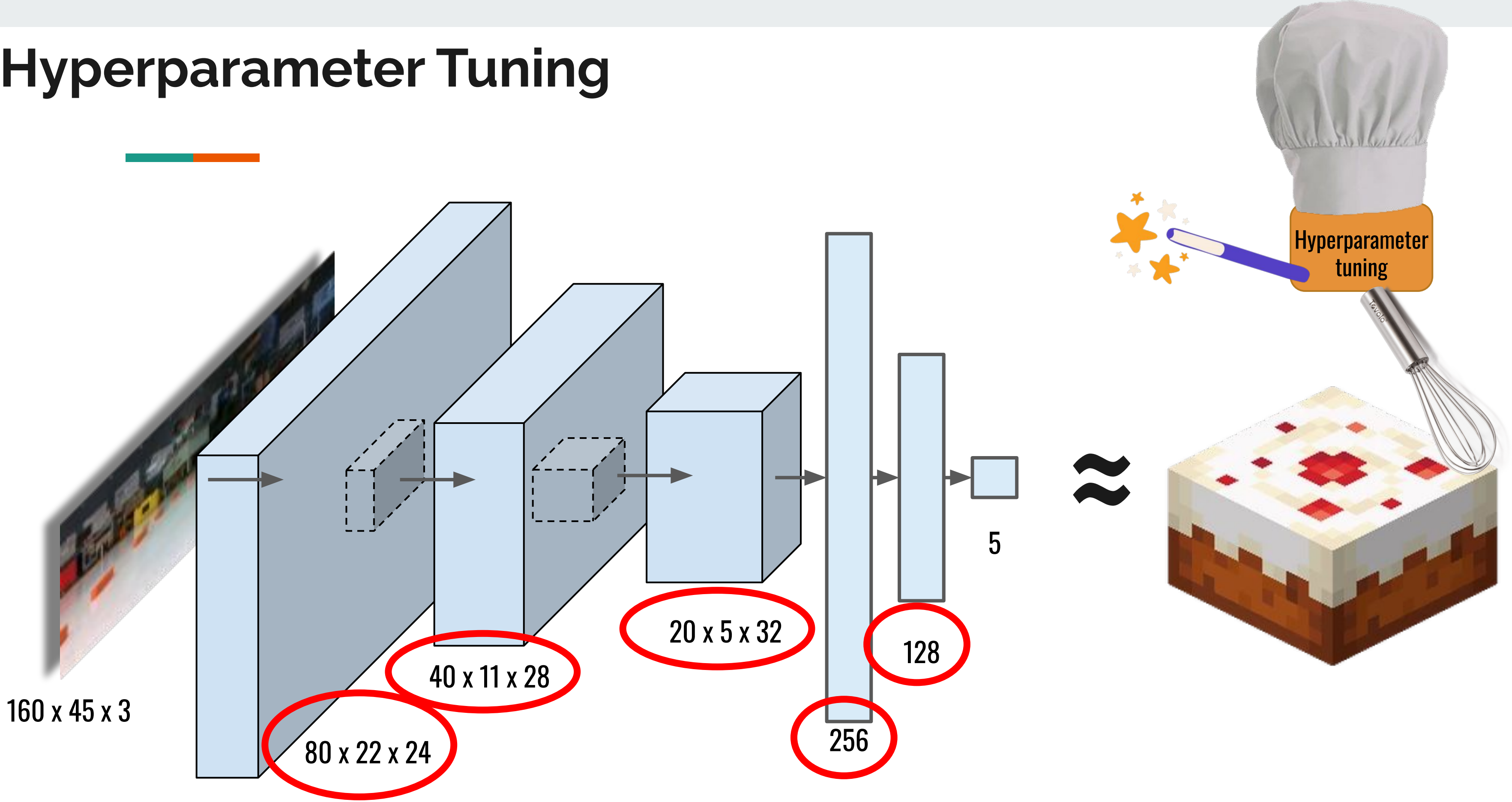


Hyperparameter Tuning

Hyperparameter Optimization Workflow



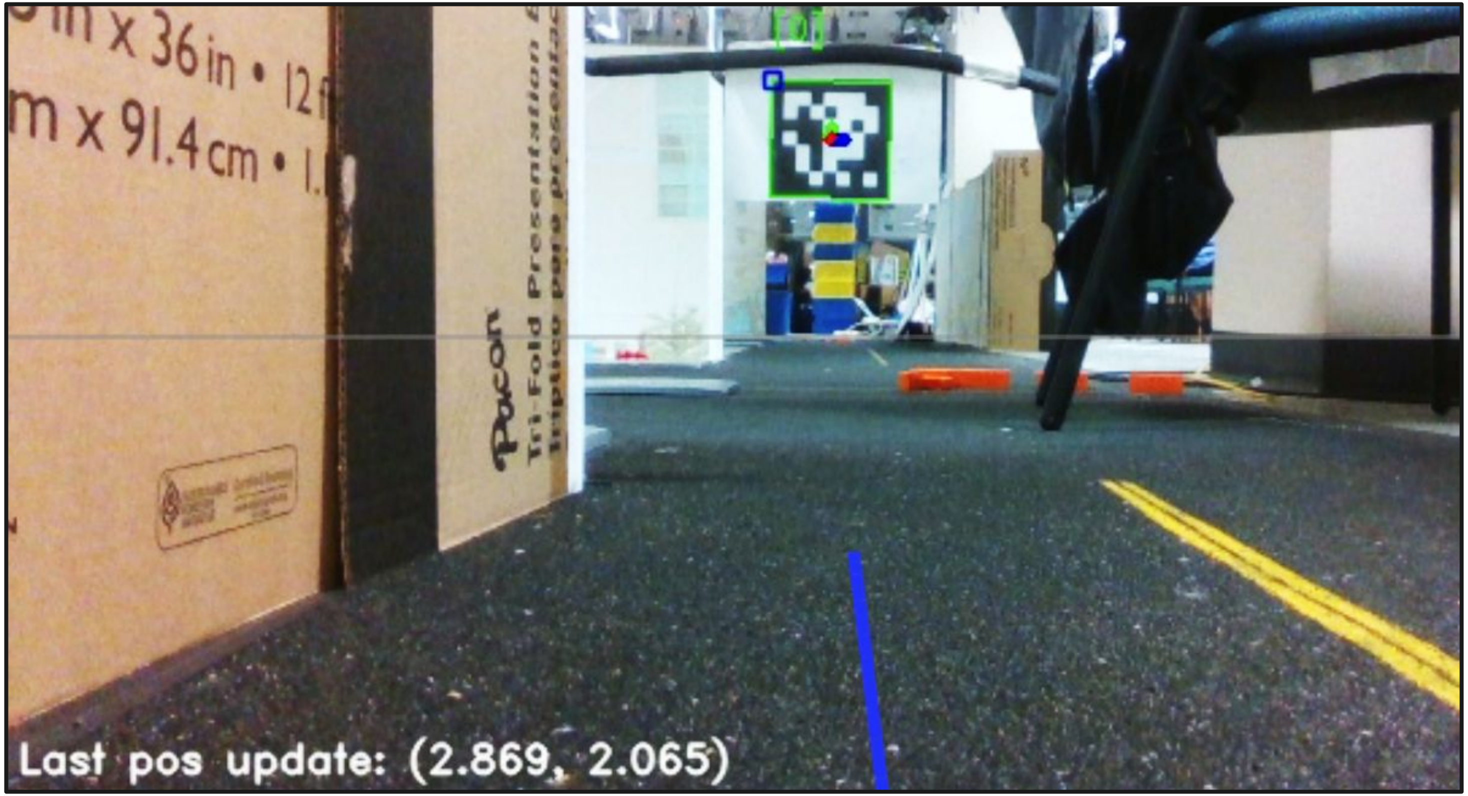
Hyperparameter Tuning



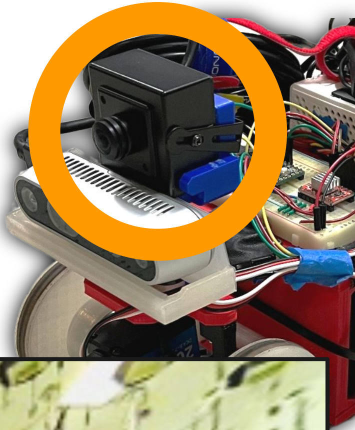
Camera Calibration + Applications

Localization:

Use ArUco detection to estimate car position.

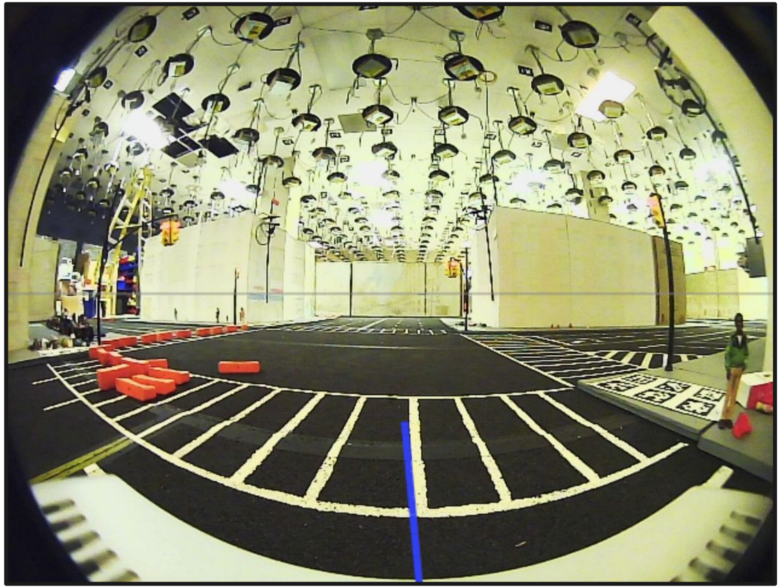


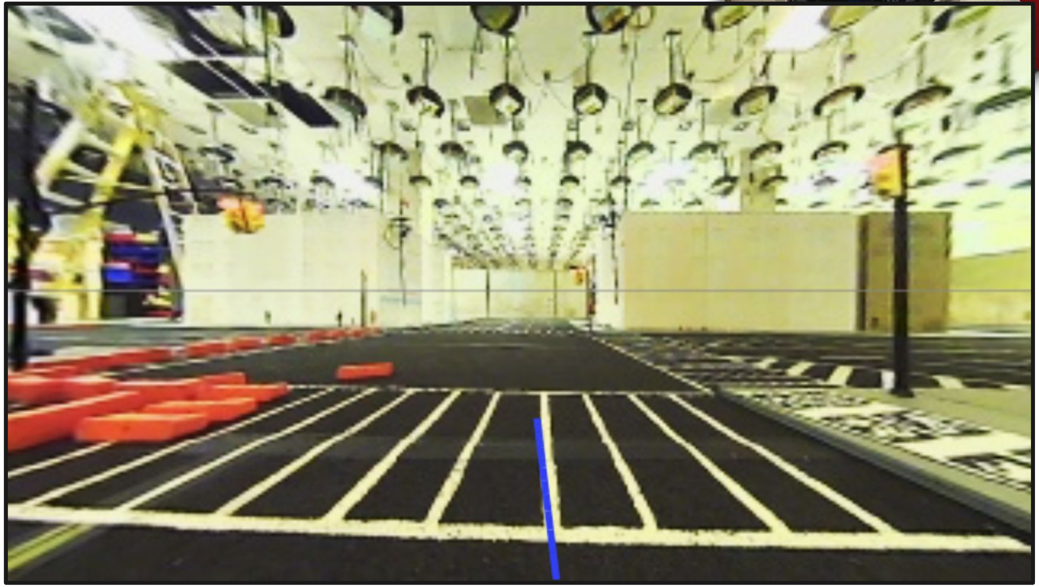
Camera Calibration + Applications



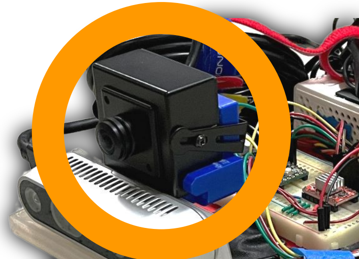
Fisheye Correction: Flatten distorted image for training.

Raw → Flattened



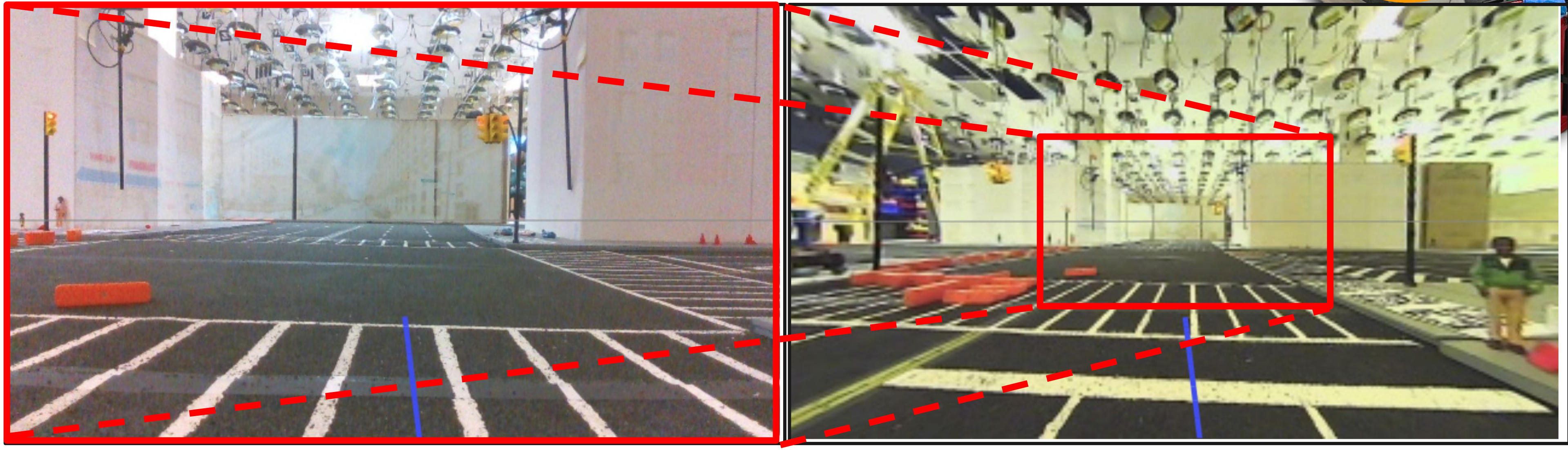


Wide FOV (Field of View)



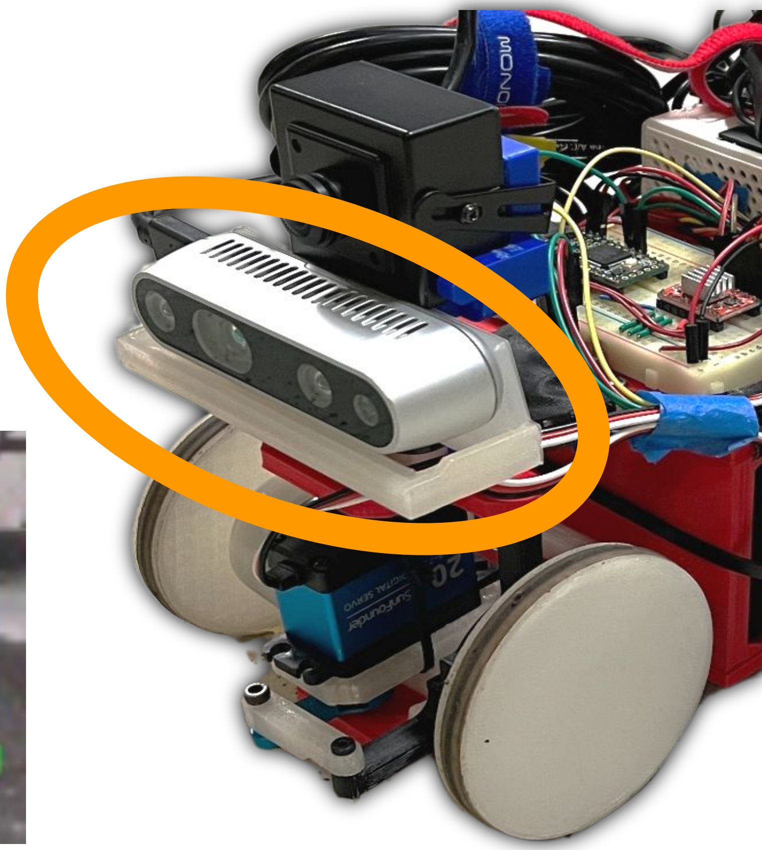
Old Camera

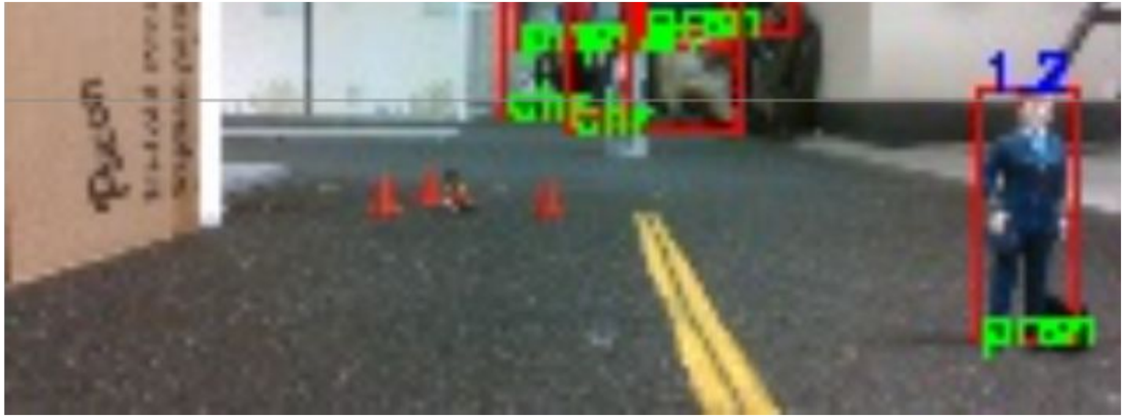
Fisheye



Old Camera (Realsense D435)

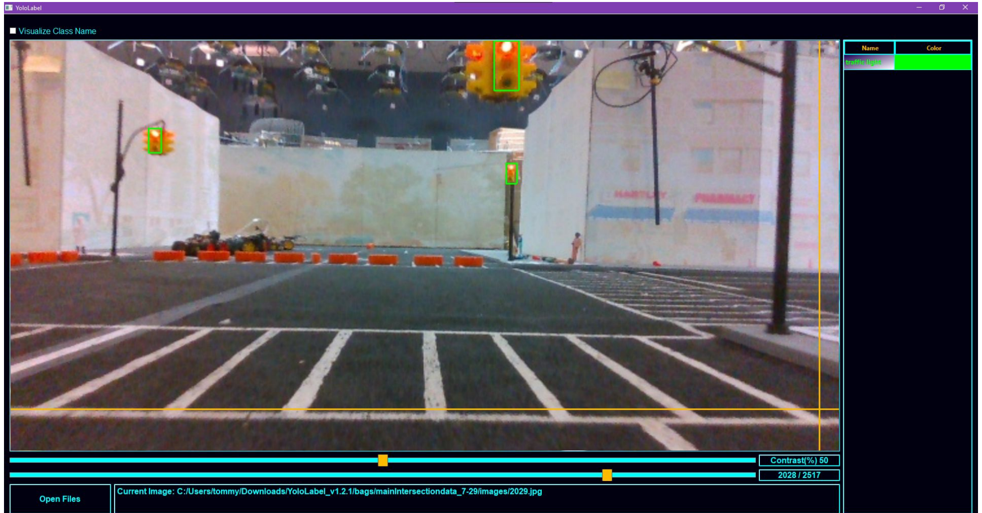
- RGBD (red-green-blue-depth)
- Object detection + Depth
  = Object position





YOLO (You Only Look Once)

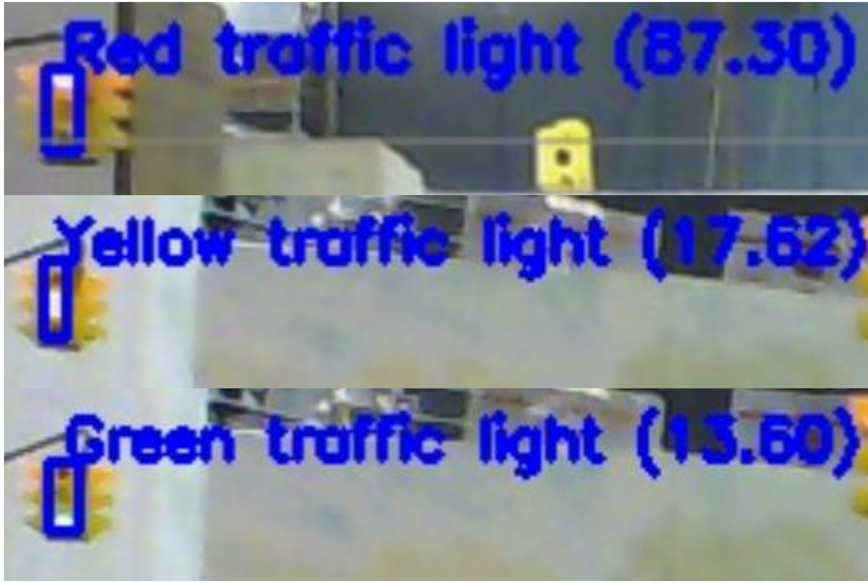
- Object detection algorithm
- Custom trained on red traffic light faces



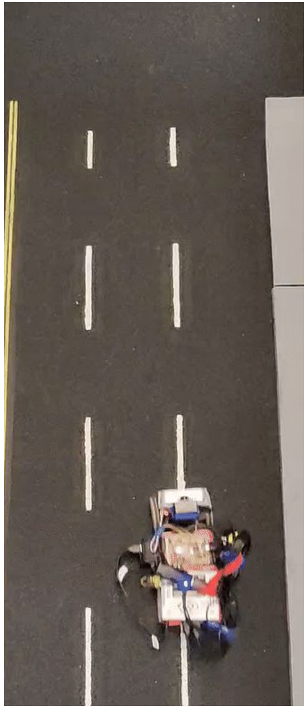
Contrast(%) 50

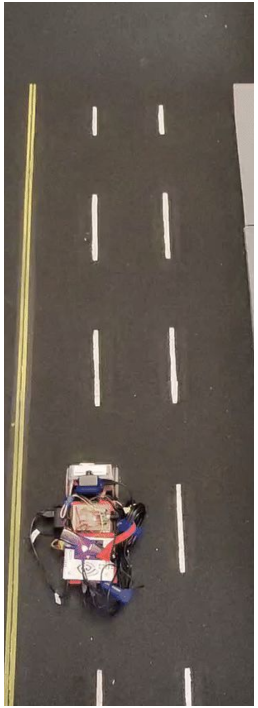
2028 / 2517

Current Image: C:/Users/tommy/Downloads/YoloLabel_v1.2.1/bags/mainIntersectiondata_7-29/images/2029.jpg

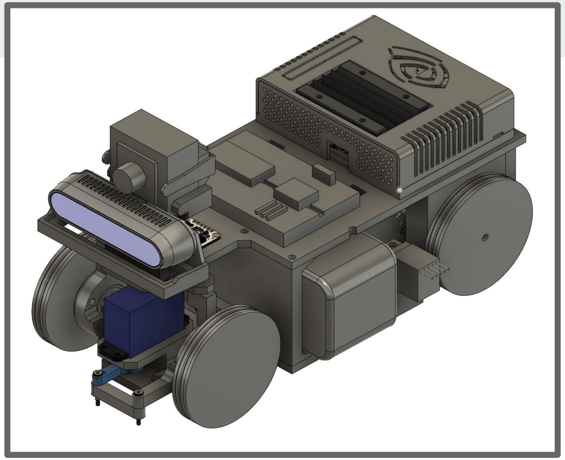

Red traffic light (87.30)
Yellow traffic light (17.62)
Green traffic light (13.60)

Results





Future Work



- Fully integrate YOLO object detection for vehicle braking
- State machine for driving intent
- Document and assemble multiple RASCAL vehicles
    - Driving with other cars

Thank you!

Live demo in the Smart City Intersection