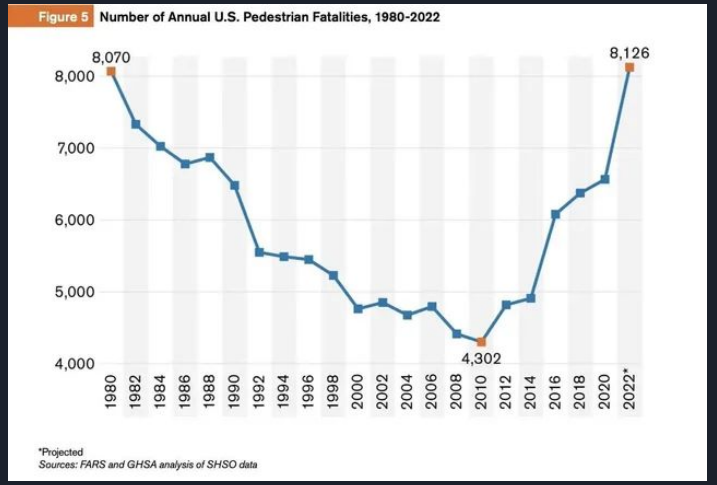
Team Wheels Final Presentation

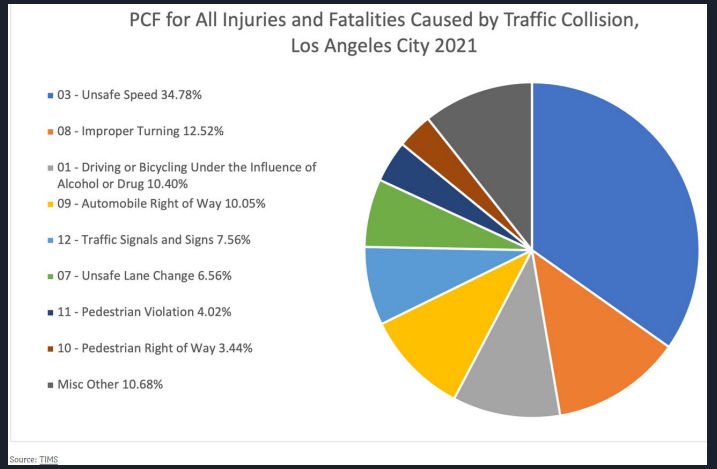
Obstacle Sensing Autonomous Car

aakashh2 | jamesey2 | gilmer2

Motivation

- Enhancing road safety
  - Ensuring lane discipline is followed
  - Maintaining safe speeds
  - Following traffic rules by recognizing traffic signs
- Ensuring pedestrian safety
  - Rising pedestrian fatalities
- Improve transportation efficiency
  - Orderly traffic = less congestion





(PCF - Primary Collision Factors)

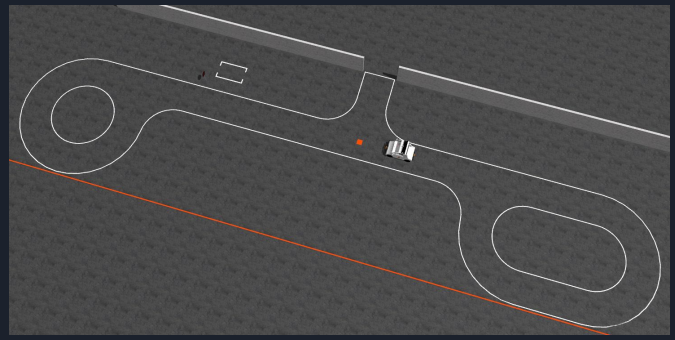
System Overview

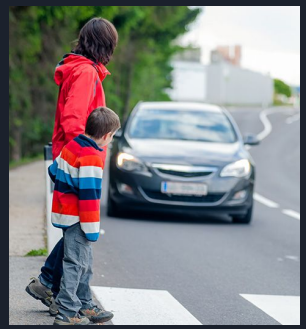
Primary Goals

- Drive autonomously within the GEM Car track
- Use only camera for perception
- Stay within the designated track lanes at all times
- Ensure comfort even while turning or braking

Additional Capabilities

- Detect pedestrians in front of the car and stop
- Detect stop signs and stop

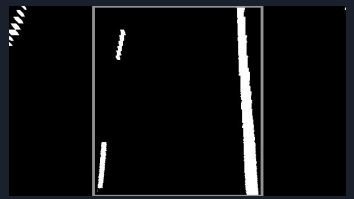




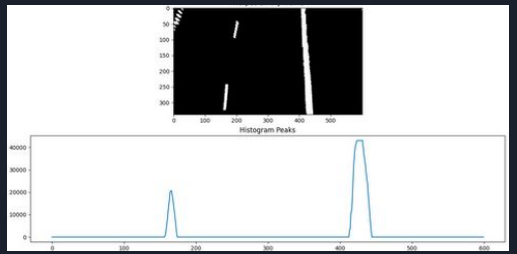
Perception: Lanes

Camera input

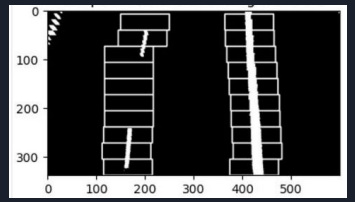
Filtered image



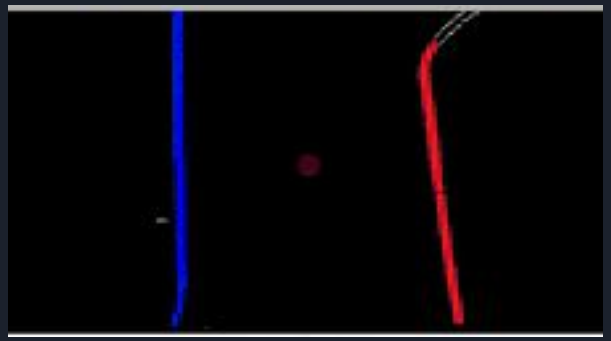
Birds-eye view



Histogram to detect lane lines



Sliding windows track lane lines

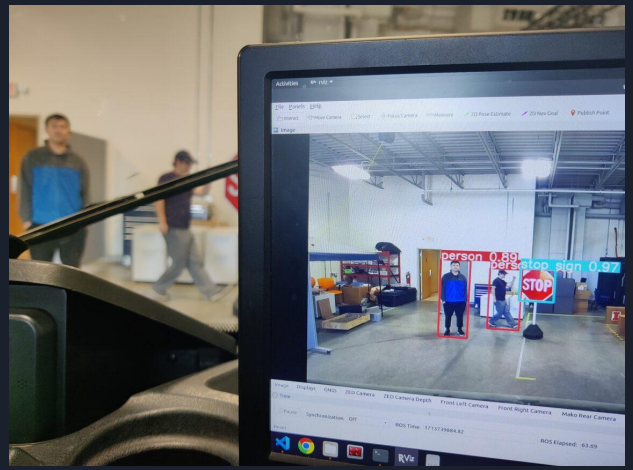


Least squares polynomial fit

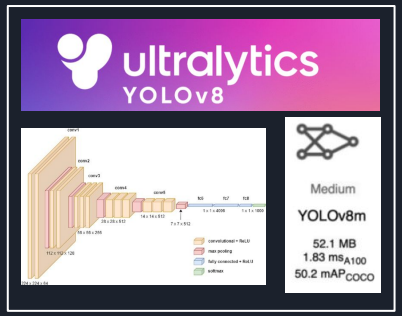
Detect lane between lane lines
and set a waypoint to follow

Perception: Obstacles

- Detect pedestrians, stop signs, and cars
- YOLOv8m
  - CNN based Computer Vision model
  - Pre-trained – detect ‘person’, ‘car’, ‘stop sign’, etc.
  - 25.9M parameters
  - Real-time performance



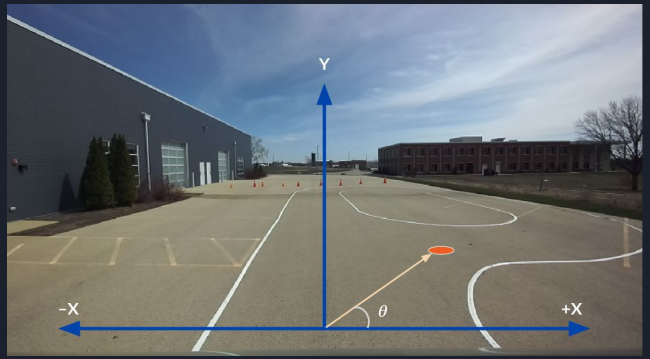
Camera input



Object detection CV model – YOLOv8m

Localization and Waypoints

- Localize using only camera; GPS and IMU not used
- Relative frame of reference
  - Car is considered to be at the origin at all times

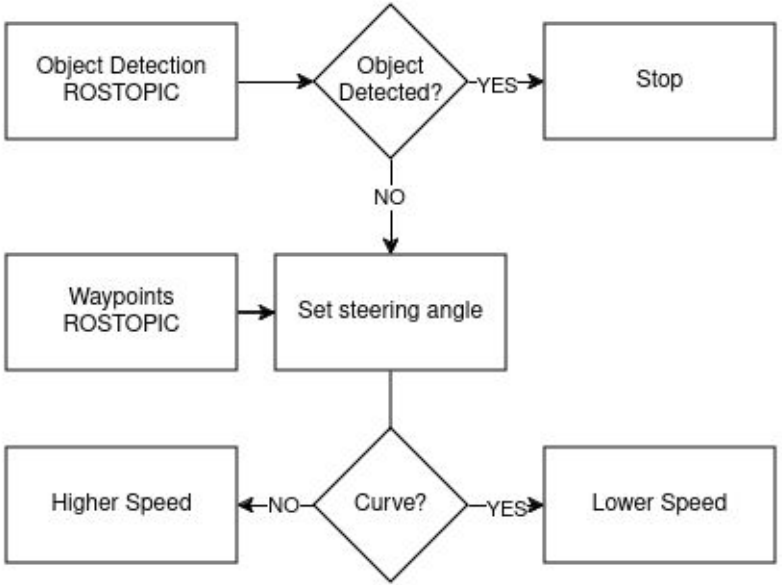


How are waypoints generated?

- When both left and right lane lines are visible –
  - Average lane pixel coordinates to get waypoint
- When only one lane line is visible – stick to that line
  - Set constant offset depending on left or right lane line

- Waypoint distance from car is proportional to current speed

Control: Flowchart



Area of bounding box around object detected is used to determine proximity.

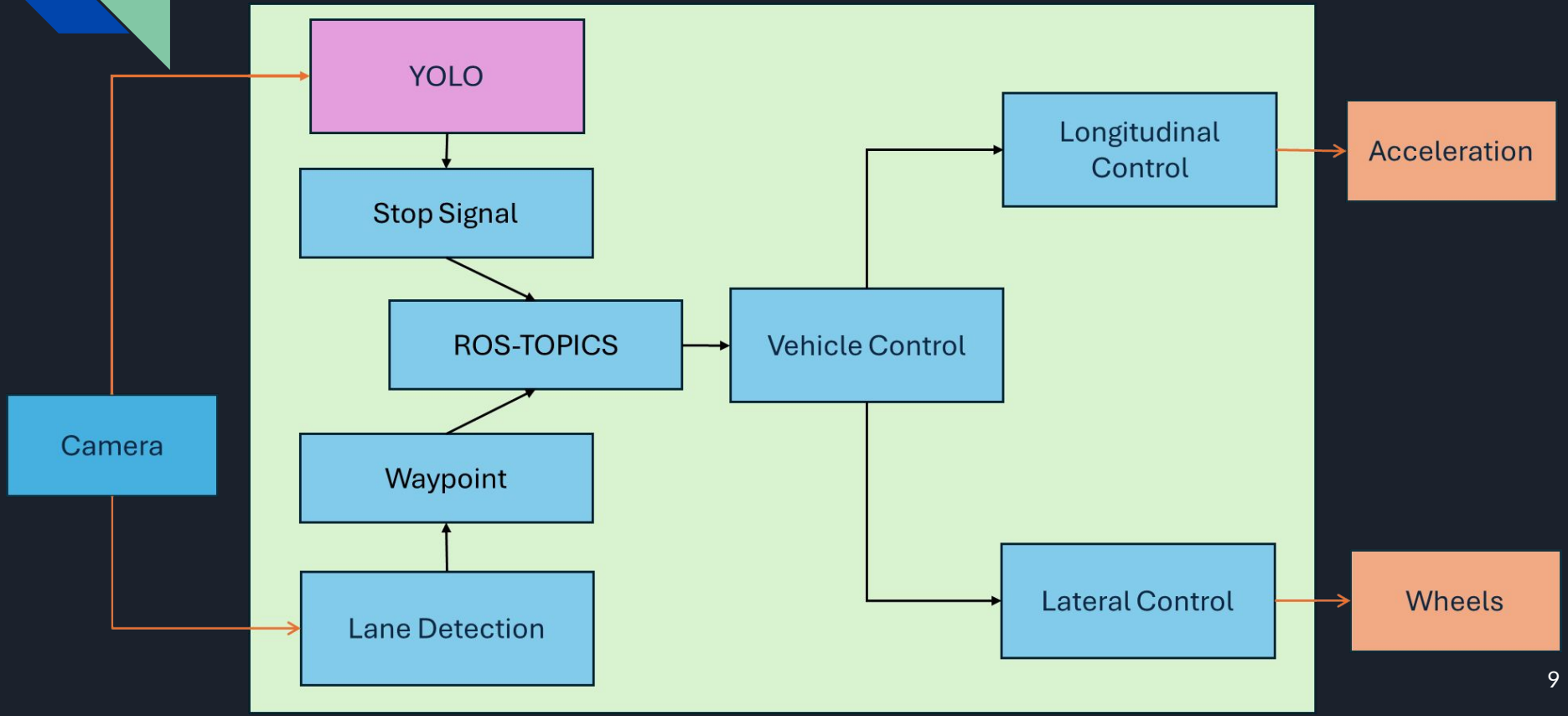
Pure Pursuit Controller is used to follow the waypoints provided.

Control: Additional Considerations

- When lane is not detected – waypoints not generated
  - Synthesize waypoints and maintain heading (for Highbay)

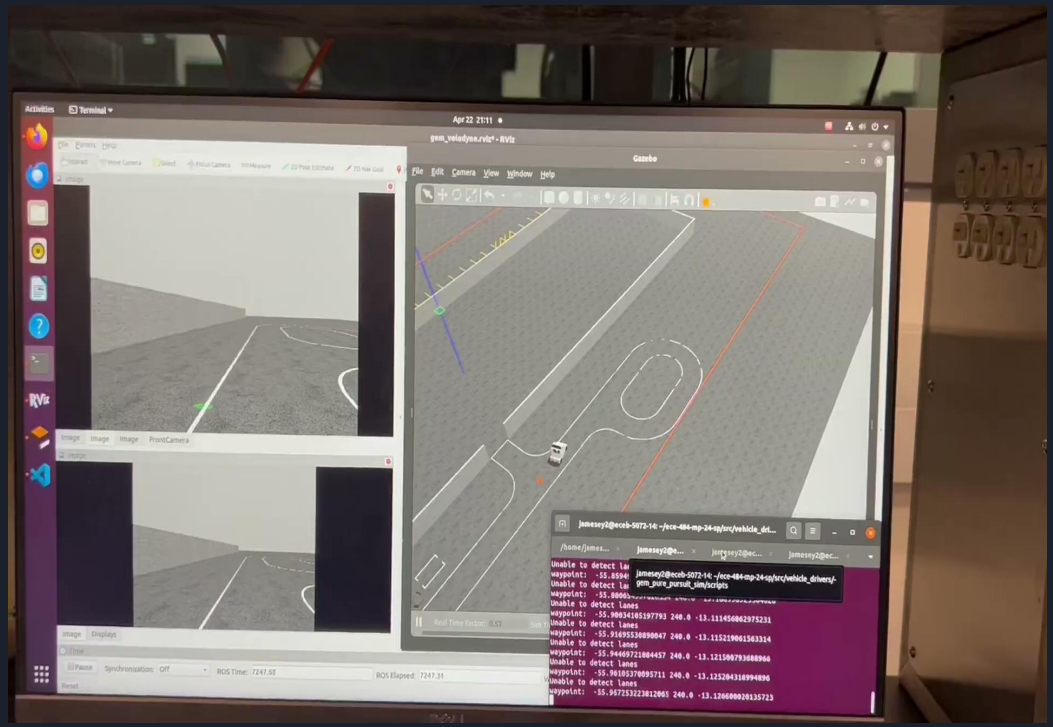
- Ensure comfort of riders
  - Slow down on turns
  - Brake gradually if possible

System Diagram



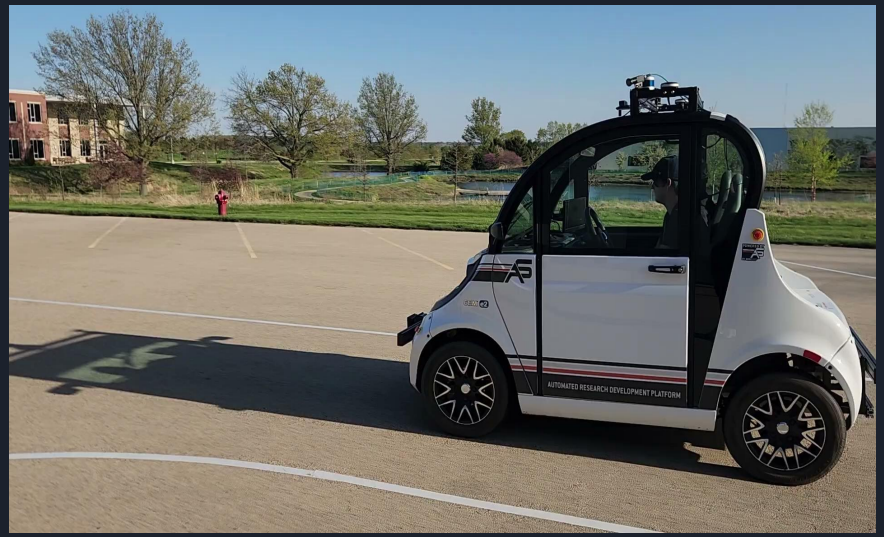
Results: Simulation

- Set up simulator as an alternative to using only Rosbags collected from the GEM car.
- Helped with –
  - Tweaking lane detection
  - Designing waypoint algorithm
  - Figuring out control strategy
- Video shows –
  - Lane following (partial)
  - Stop sign detection

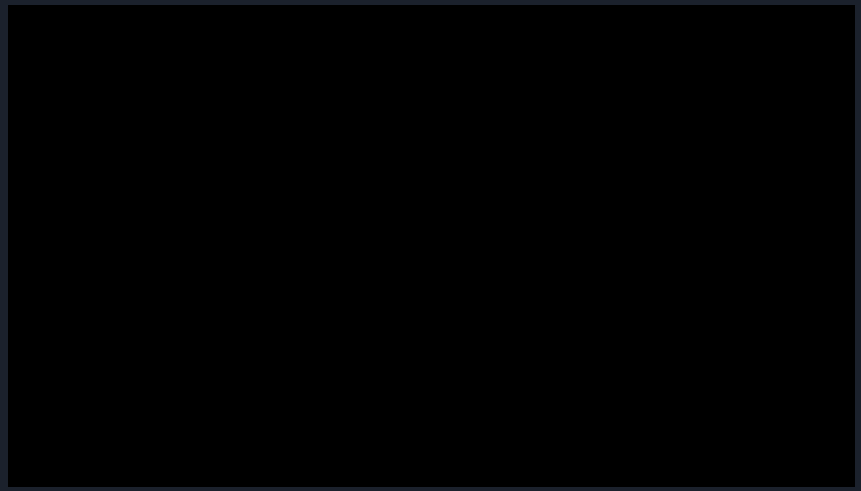


Results: GEM Highbay track

Results: GEM Stop Sign Detection



Results: GEM Pedestrian Detection



Difficulties and Limitations

- Lane detection
  - Lanes get crossed very easily and are difficult to restabilize
  - Finding a solution for waypoints when only one lane is visible
  - Narrow lanes at Highbay – requires sharp turns
  - Narrow camera POV – lanes go out of sight
- Working with the provided car dynamics code
  - Hard to understand how PID for steering and speed works
- Weather affects performance of algorithm
  - Cloudy vs sunny
  - Rain and snow – will break lane detection

Thank you!

Tasks Remaining

- Improve lane detection
  - Remove inconsistencies in some corner cases
- Improve waypoint following
  - Smoothen steering – can be done using PID
  - Try to maintain the lane at higher speeds