Simulation-Based Autonomous Driving in Crowded City

Final Task - Final Presentation

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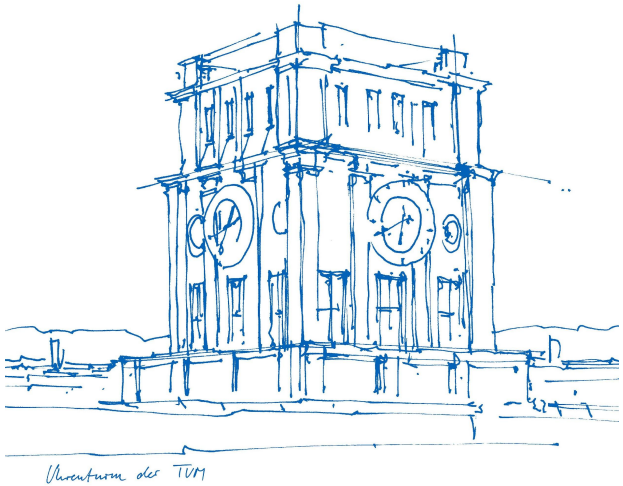
Michael Sodamin

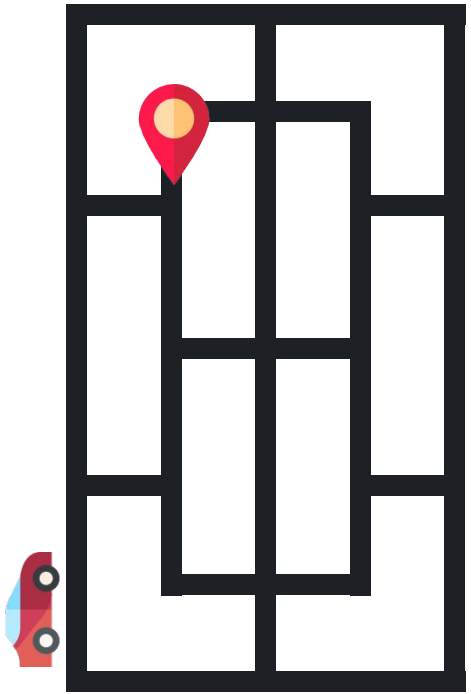
Supervisor: Liguo Zhou

Munich, 11.09.2023



Overview

1. General Approach
2. Training a Model
3. Deploying the Model
4. Evaluation
5. Demo



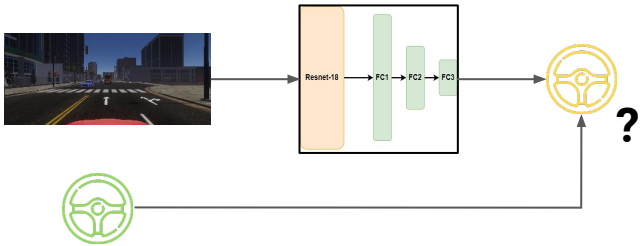
General Approach

1. Collect Dataset

Images

VehicleData

2. Train a model



Training

Deployment

General Approach

1. Collect Dataset

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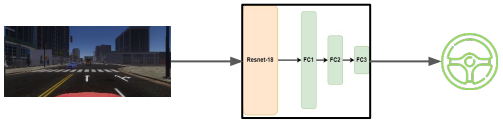
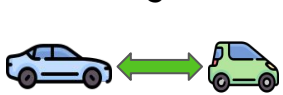
2. Train a model

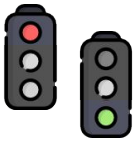
Training

1. Steering Model

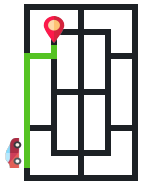


2. Detect Surroundings





3. Follow Route



Deployment

General Approach

1. Collect Dataset

Images

VehicleData

2. Train a model

Training

1. Steering Control

2. Detect Surroundings

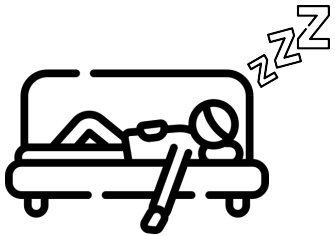
3. Follow Route

Deployment

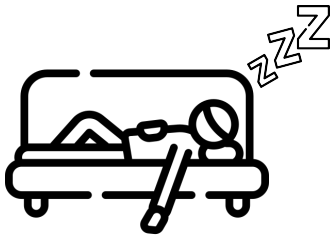
Data Collection - Manual

- Time consuming
- Mistakes in data
- Inconsistent driving behavior

Data Collection - Automated

+ No mistakes
+ Consistent driving behavior
+ Speed up simulator time
+ 

Data Collection - Automated

+ No mistakes
+ Consistent driving behavior
+ Speed up simulator time
+ 

But: Bad Performance!

Data Collection - Automated

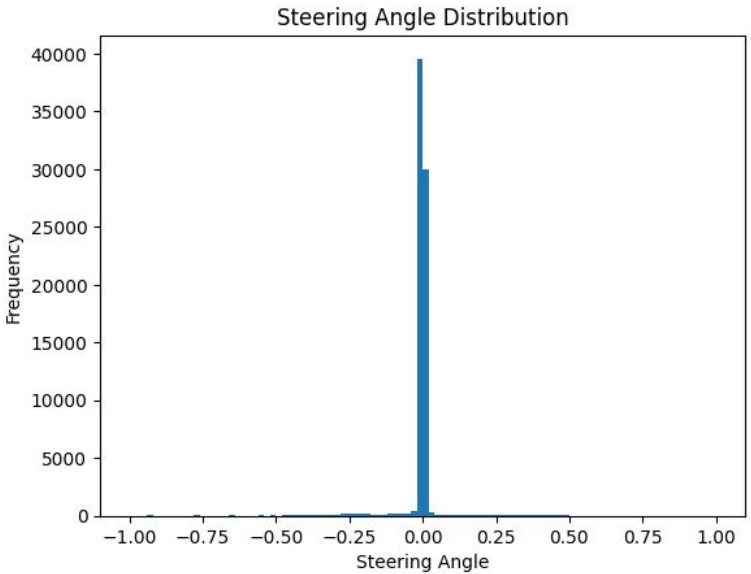
Car doesn't turn?

Recover from bad situation?

Data Collection - Balancing

Car doesn't turn?

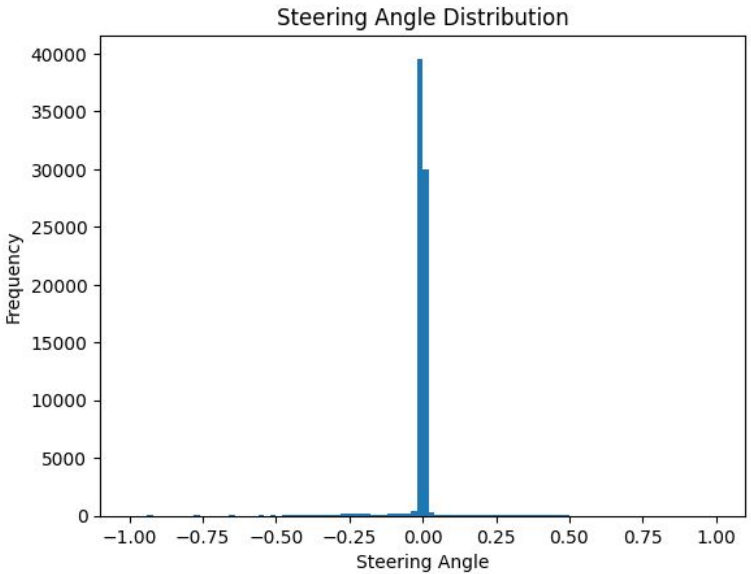
Recover from bad situation?

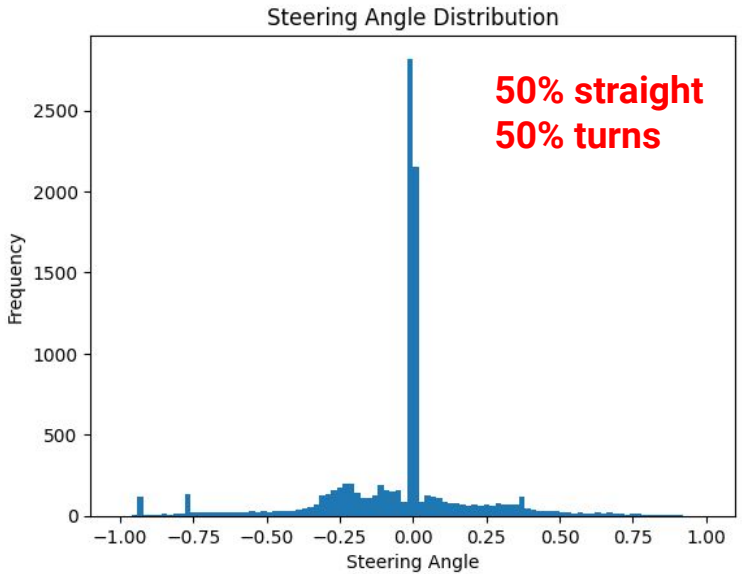


Data Collection - Balancing

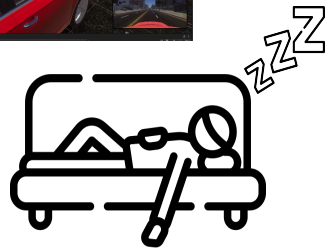
Car doesn't turn?

Recover from bad situation?





Data Collection - Hybrid Data Collection



Car doesn't turn?

Recover from bad situation?

Data Collection - Hybrid Data Collection

Car doesn't turn?

Recover from bad situation?

&

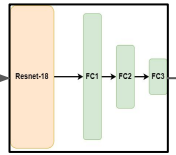
As in [1]: Expert remains in the loop, Codevilla et. al.

General Approach

1. Collect Dataset

Images VehicleData

2. Train a model



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Training

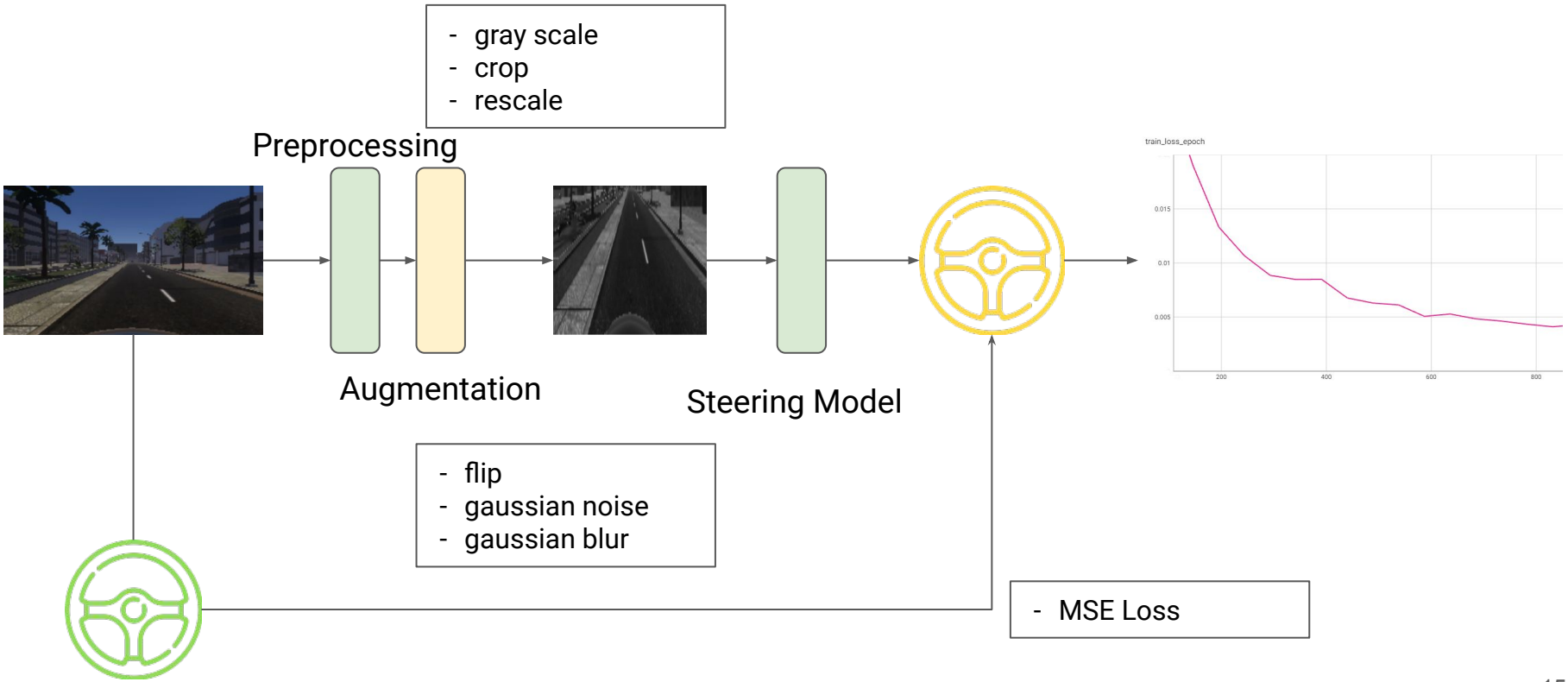
1. Steering Model

2. Detect Surroundings

3. Follow Route

Deployment

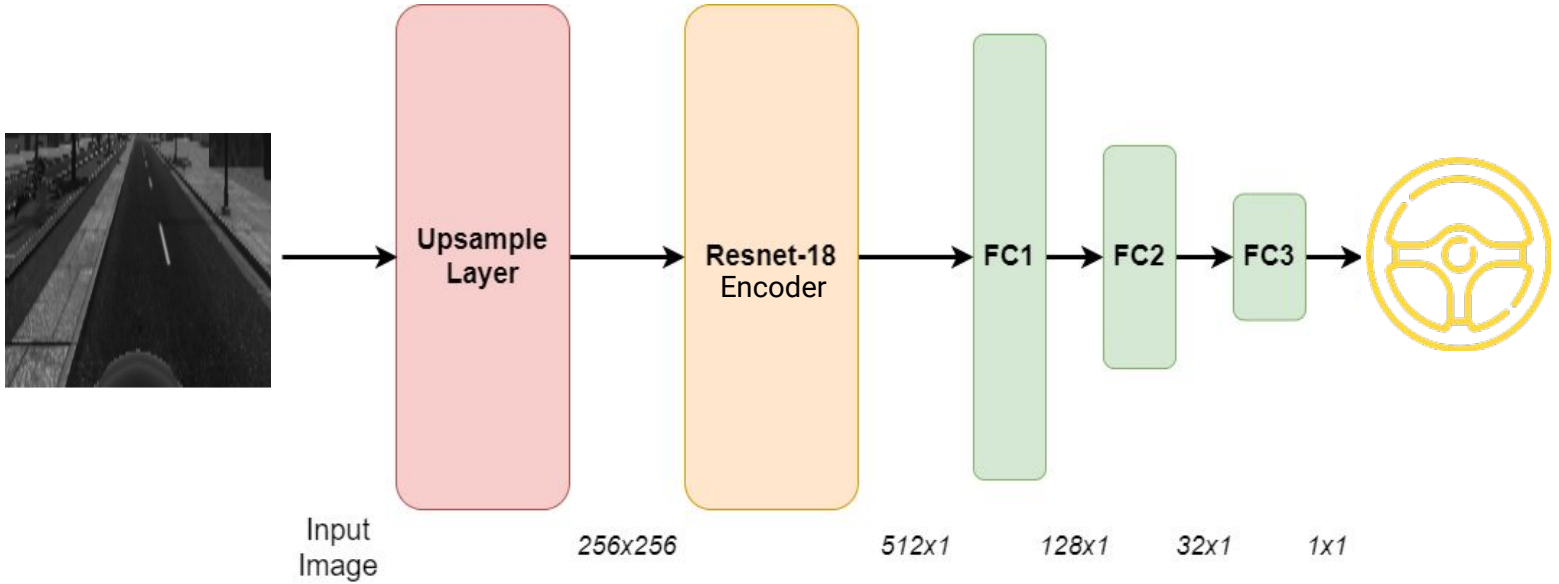
Steering Model - Training



Steering Model - Architecture

~~CNN LSTM~~

~~CSP SG~~



General Approach

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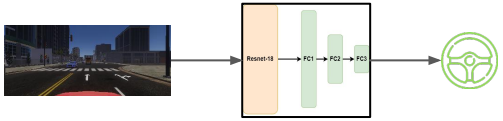
Training

1. Steering Model

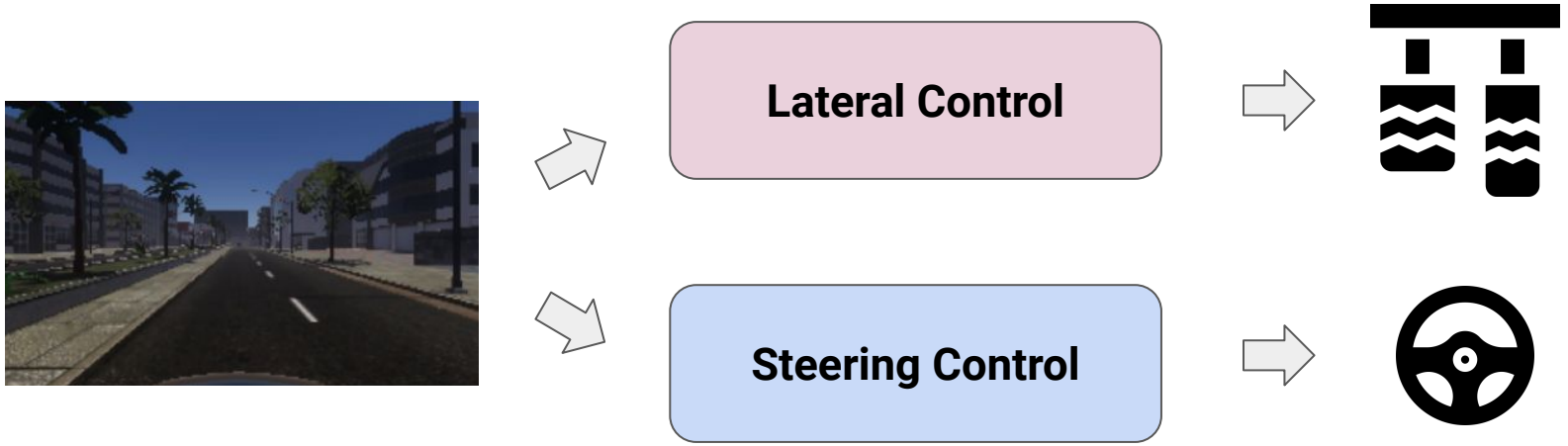


2. Detect Surroundings

3. Follow Route

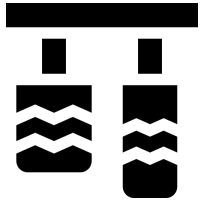
Deployment

Deployment - Software Architecture



Deployment - Software Architecture

Lateral Control

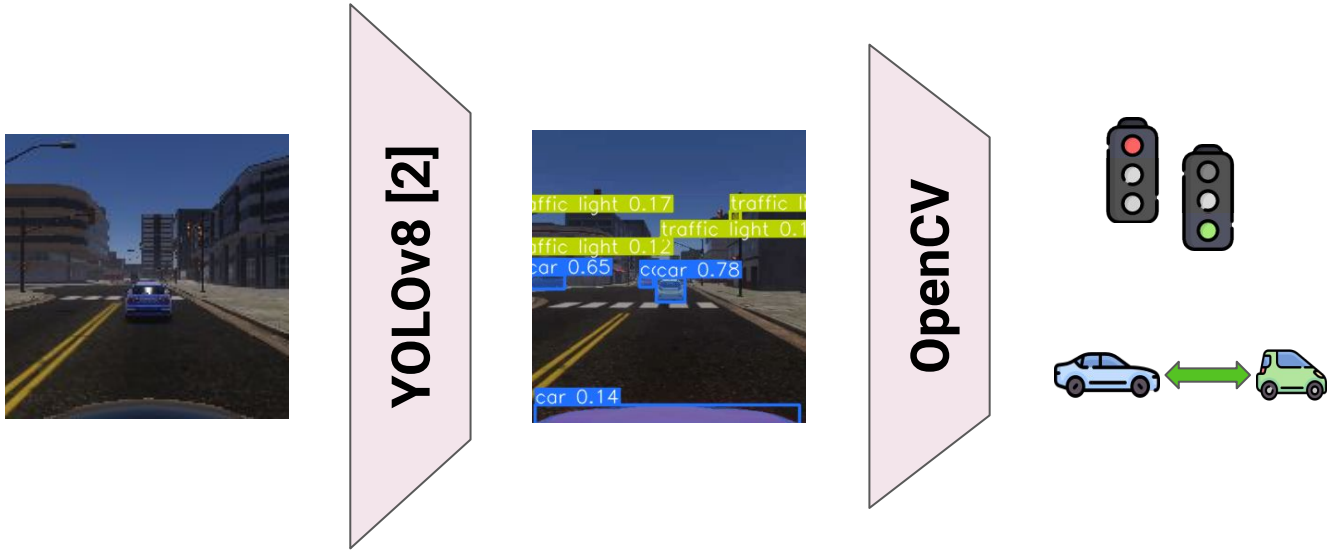


Steering Control

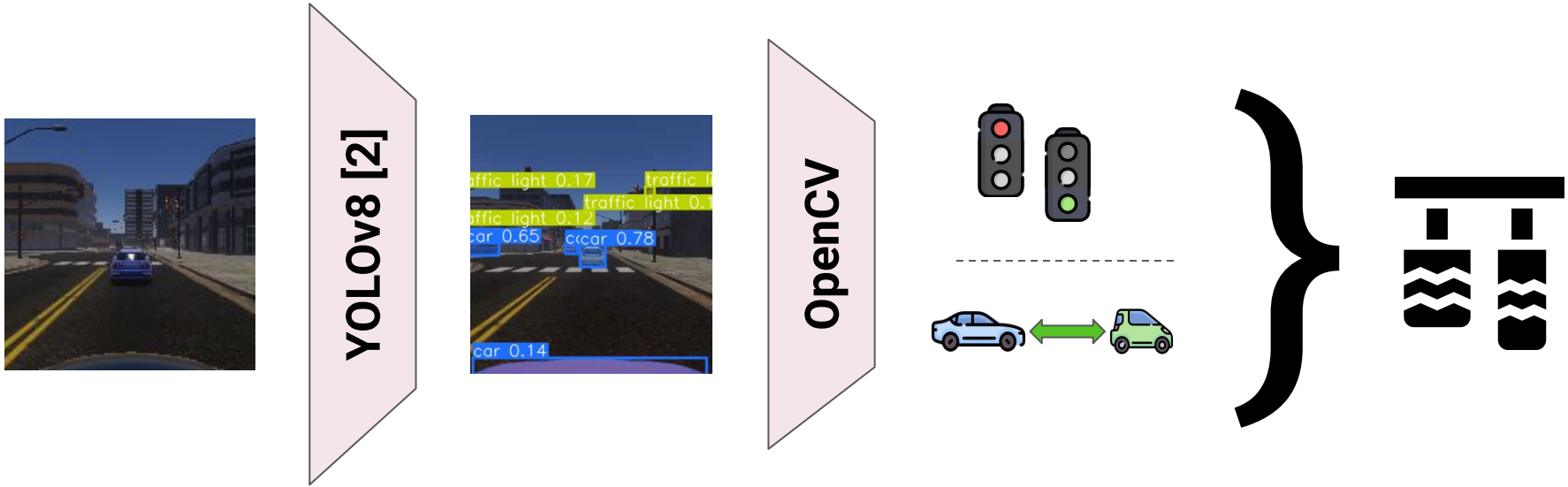
Deployment - Detection

YOLOv8 [2]

Deployment - Detection

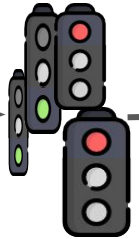


Deployment - Detection

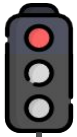


How the Traffic Light Detection works.

Crop Traffic Lights
! Change Thresholds !



HSV Filtering
Find traffic light with most amount of color

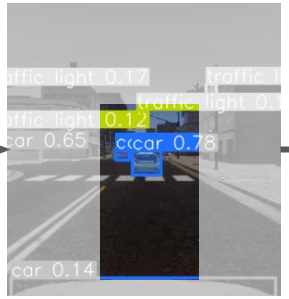


#colored_pixels > threshold?

React to Traffic Light! (e.g. brake / drive)

How the Distance Detection works.

Focus on cars in front

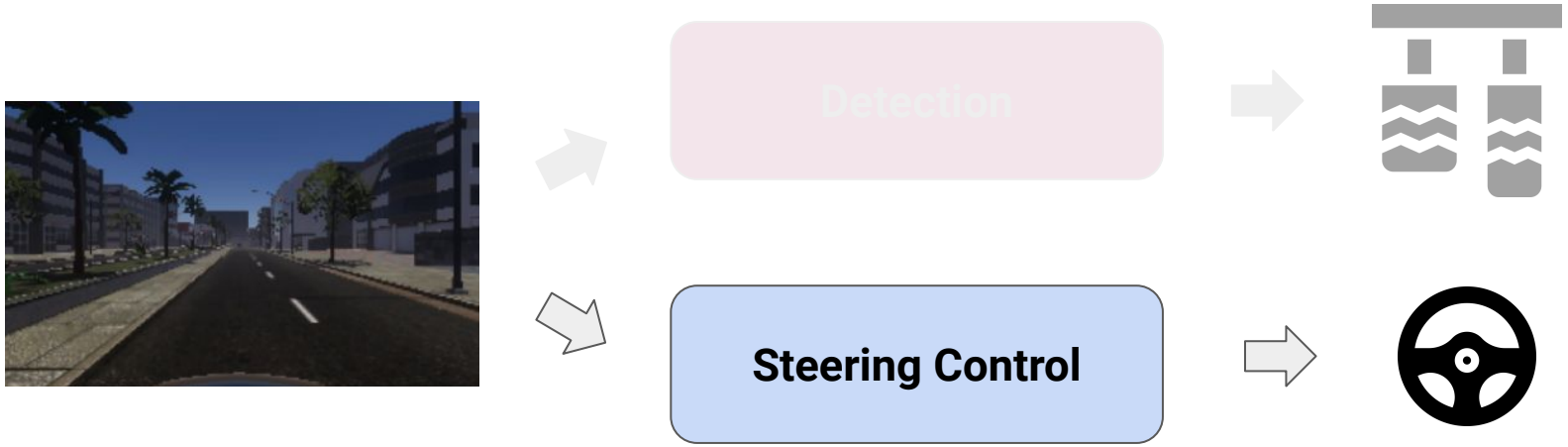


Select Closest Bounding Box
Only Vehicles are Considered

Closest y-Coordinate > threshold?

Brake.

Deployment - Steering Control



Deployment - Steering Control

Deployment - Steering Control

How does the model know where to go?

General Approach

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Training

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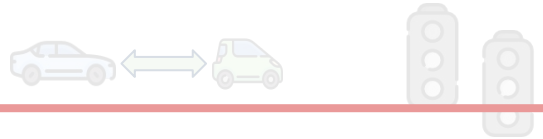
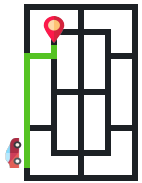
2. Detect Surroundings

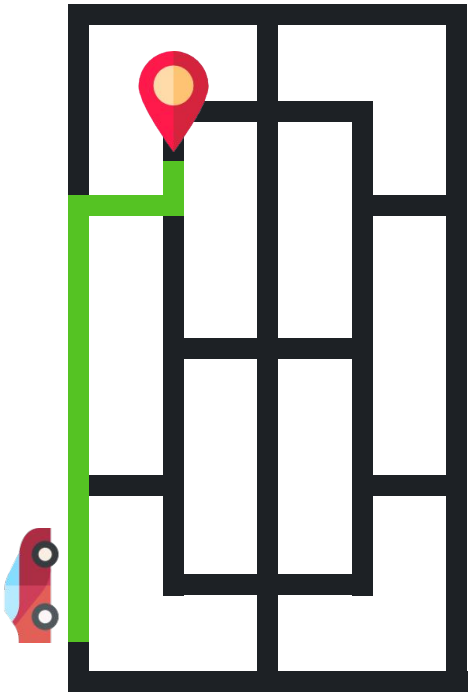


3. Follow Route



Deployment

Deployment - Navigation



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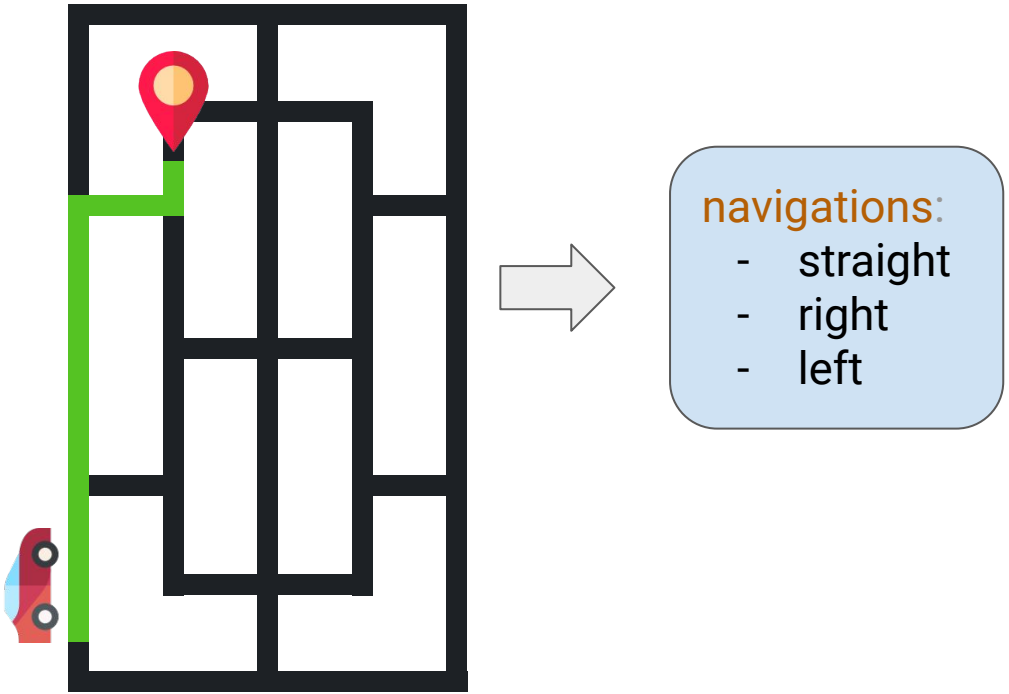
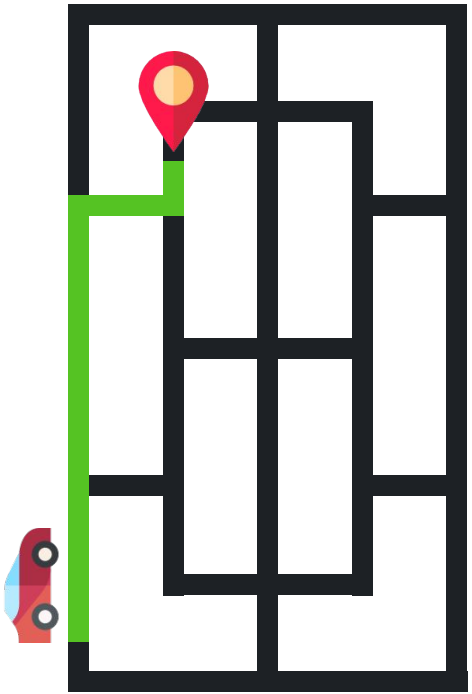


navigations:
- straight
- right
- left

Deployment - Navigation



navigations:
- straight
- right
- left

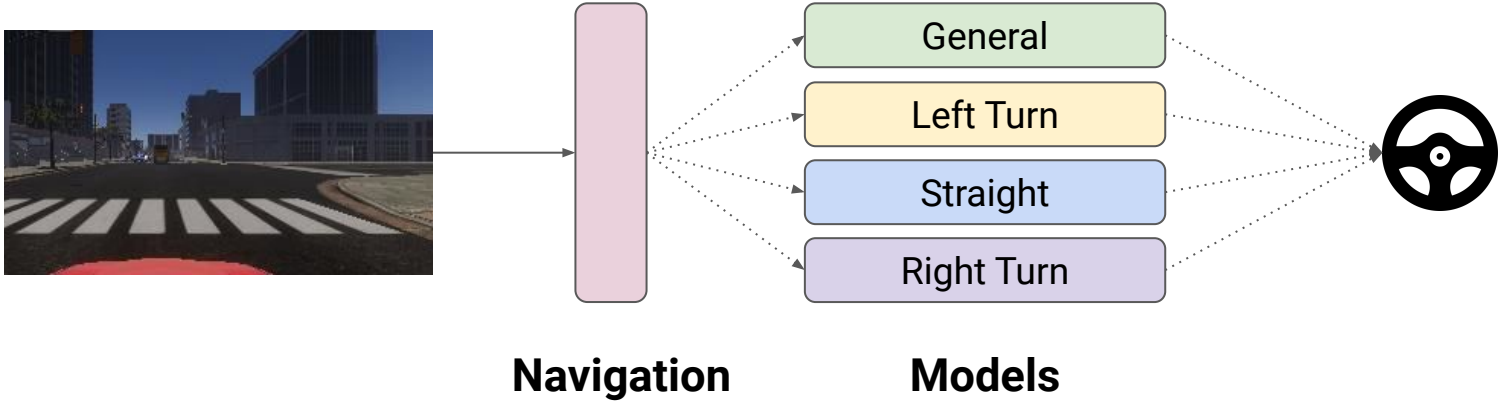
How to follow a route?

Intersection Counter
(Traffic light available?)

Specific model for each direction

Approach similar to *command-conditional imitation learning* from Codevilla et. al. [1]

Deployment - Navigation



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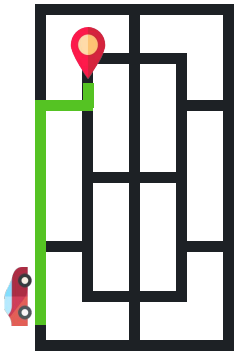

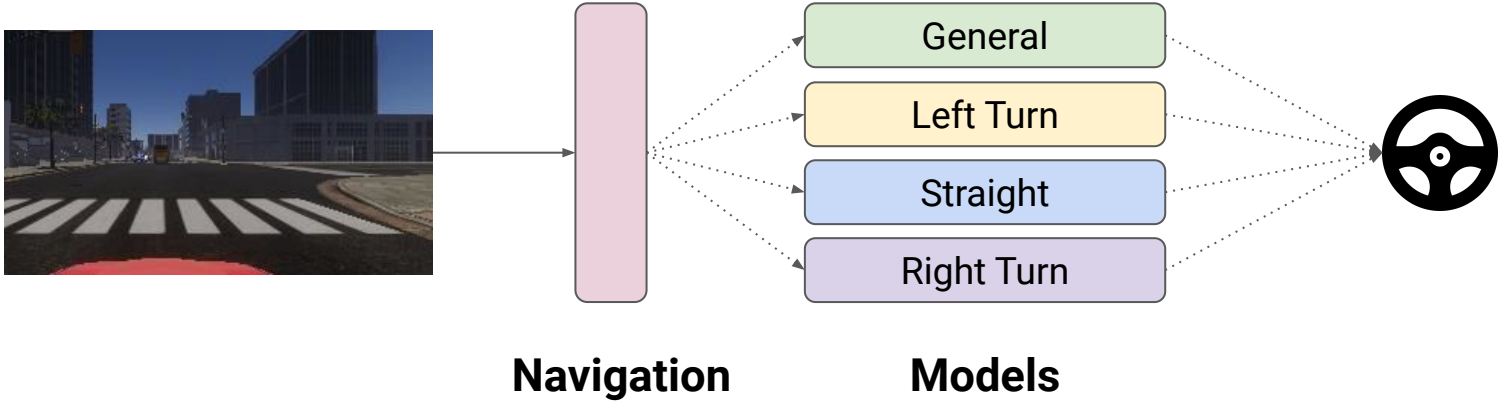

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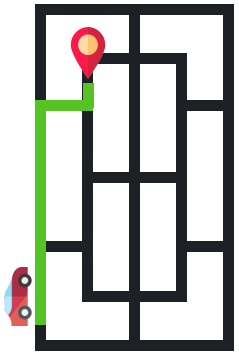

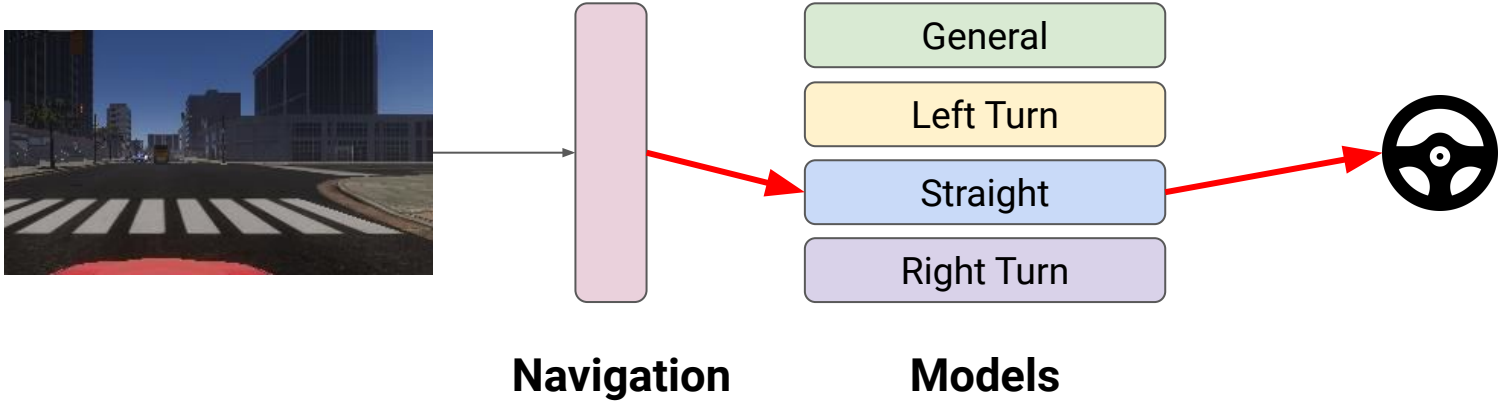

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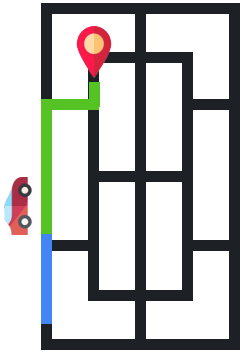

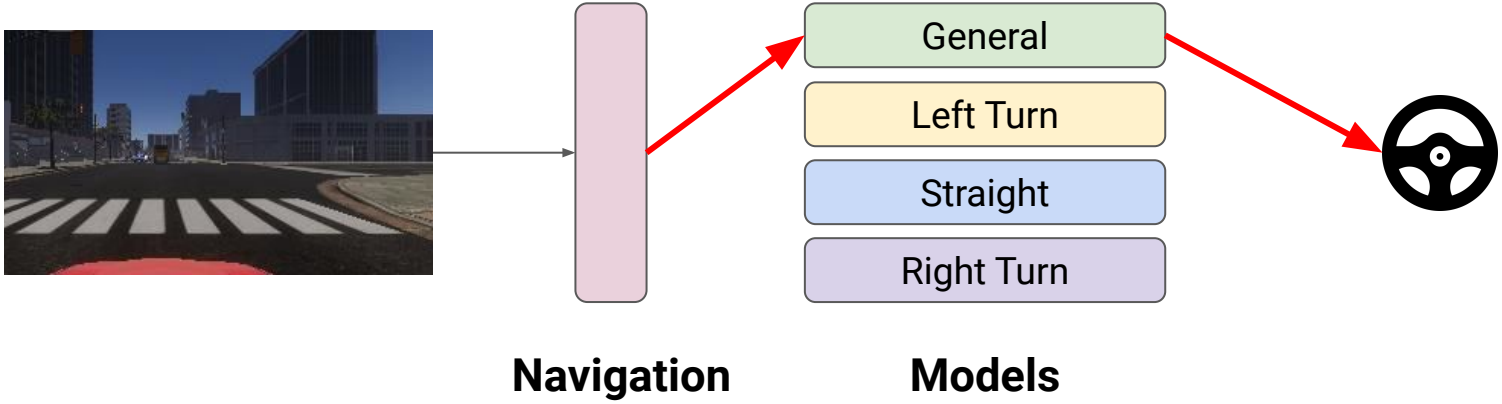

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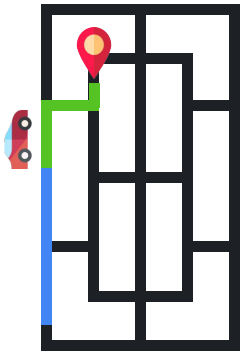

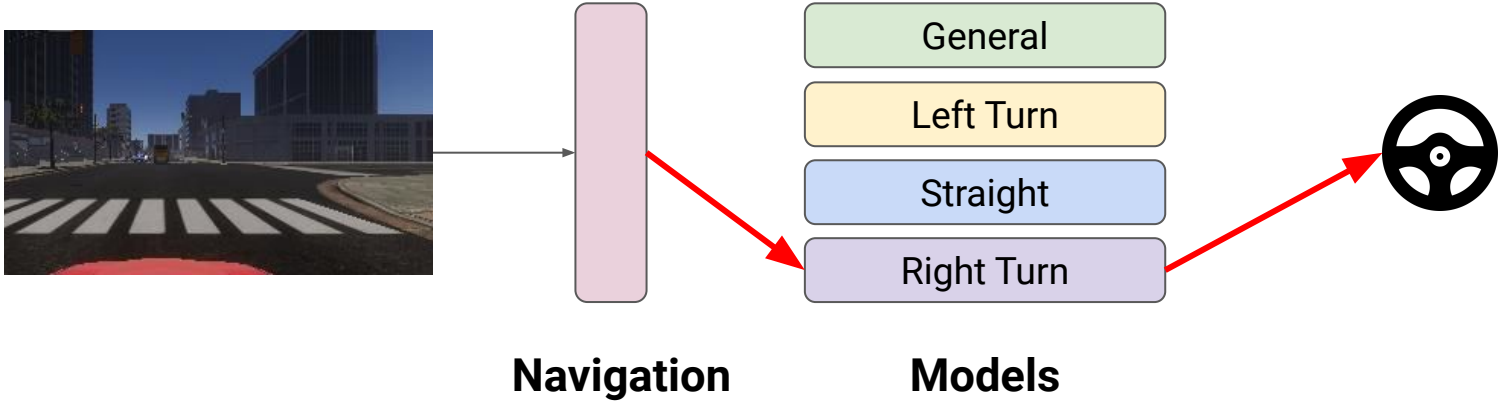

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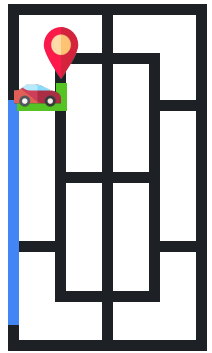

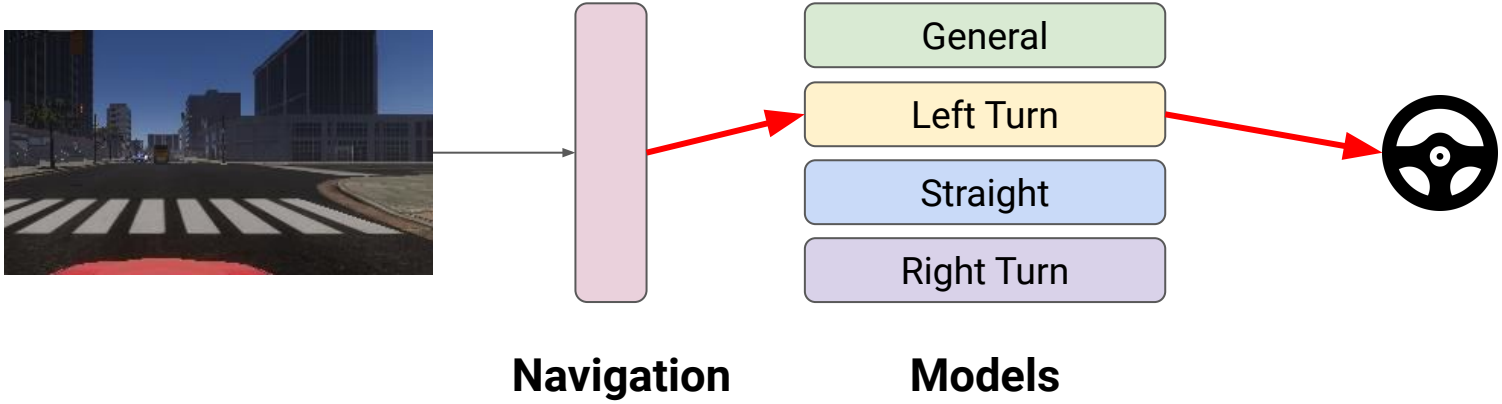

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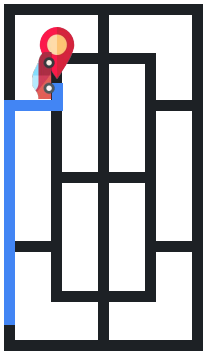
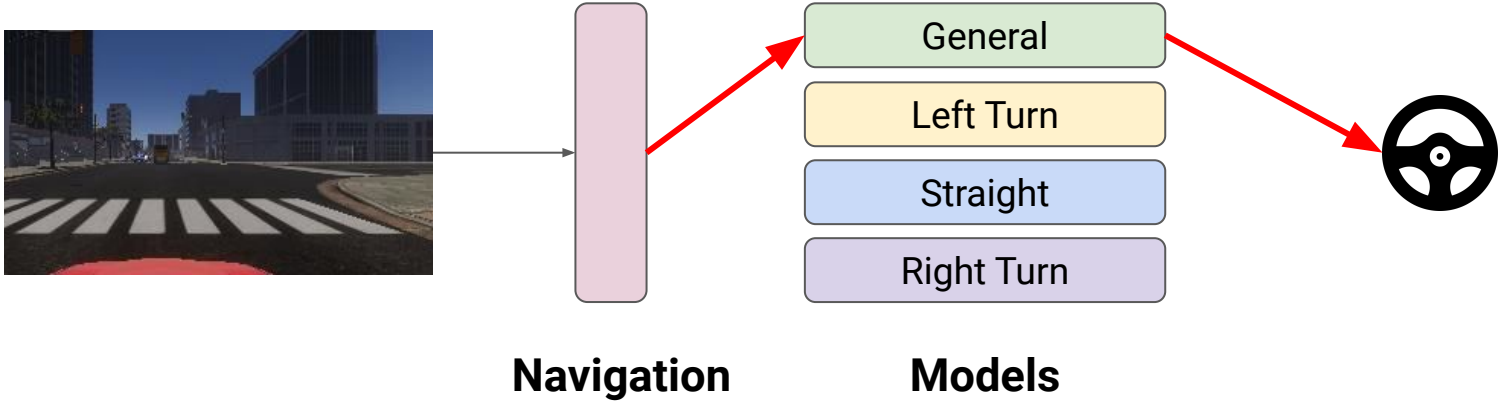


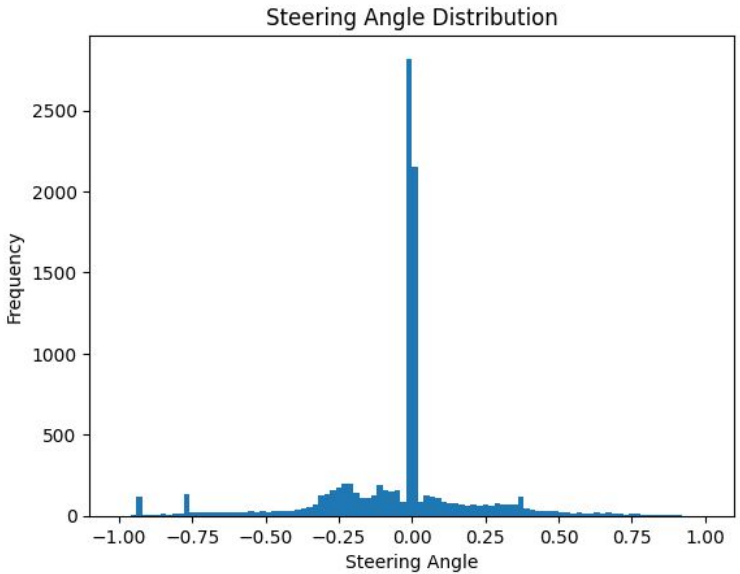


How to train intended Behavior?

How to train intended Behavior?

Filter the Training Data.

How to train intended Behavior?



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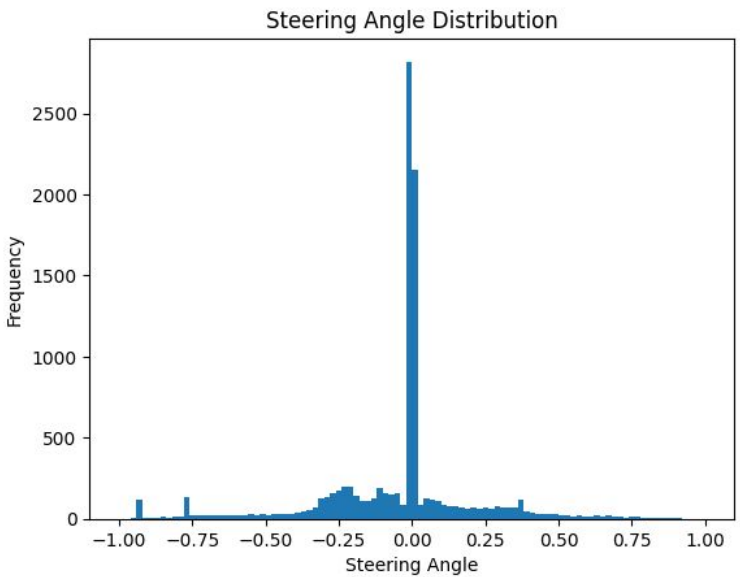
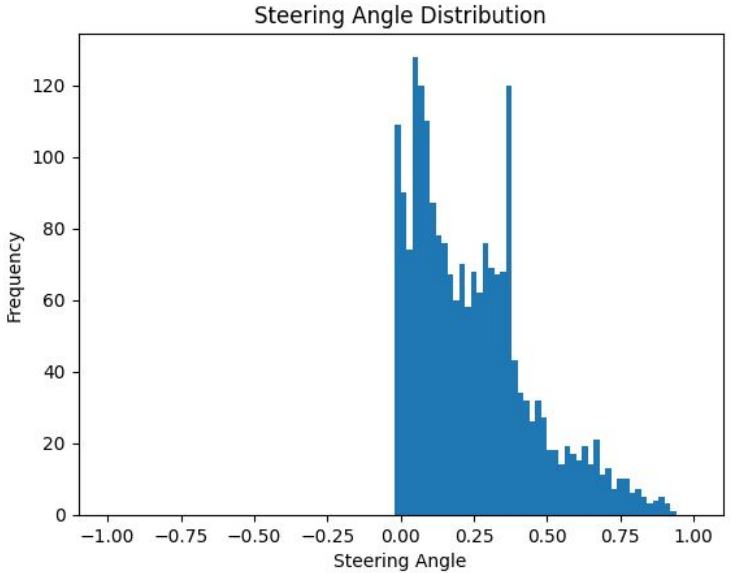
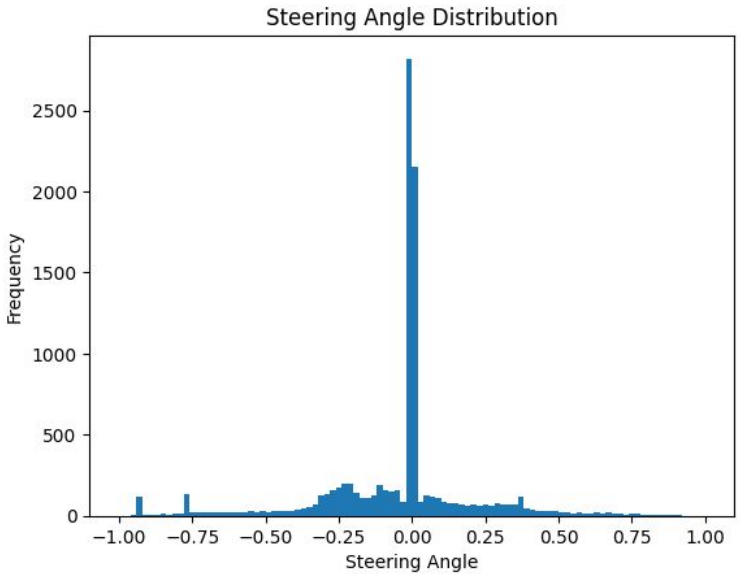
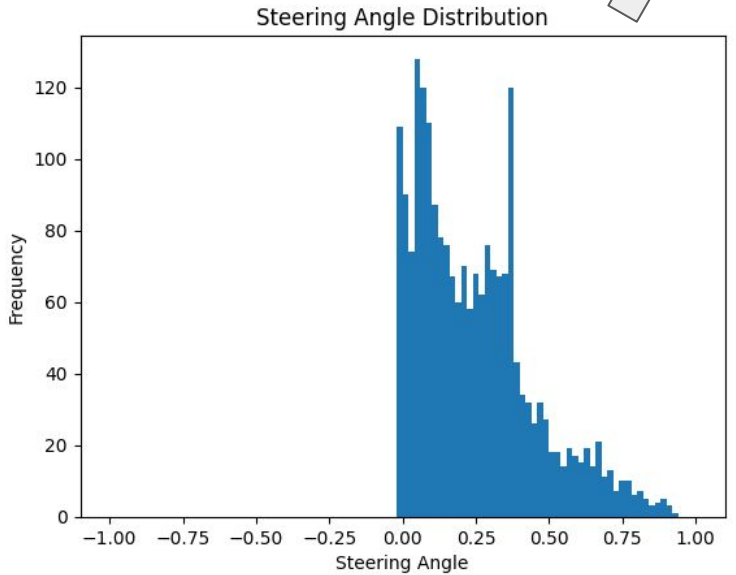




How to train intended Behavior?

Right Turn Model





General Approach

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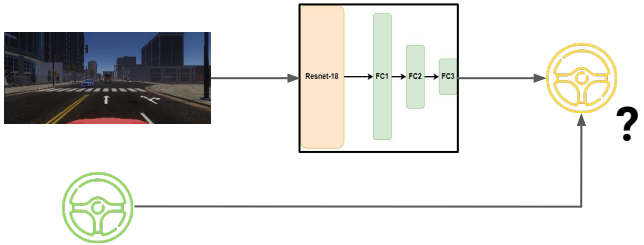
Images

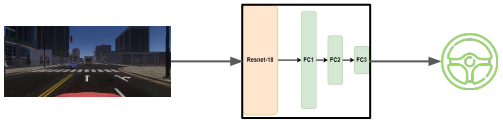
VehicleData

2. Train a model



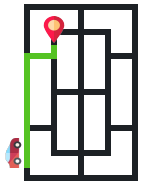
Training

1. Steering Model



2. Detect Surroundings

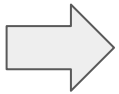
3. Follow Route



Deployment

Evaluation

Navigations	Run 1	Run 2	Run 3
left, left	*PASSED*	*PASSED*	*FAILED*
left, right	*PASSED*	*PASSED*	*PASSED*
straight, left	*PASSED*	*PASSED*	*FAILED*
straight, straight	*FAILED*	*FAILED*	*FAILED*
straight, right	*PASSED*	*FAILED*	*PASSED*
right, left	*PASSED*	*PASSED*	*PASSED*
right, right	*PASSED*	*PASSED*	*PASSED*



35 intersections passed 

6 intersections failed 

1 not reached

Demo

On the unmodified Original Simulator

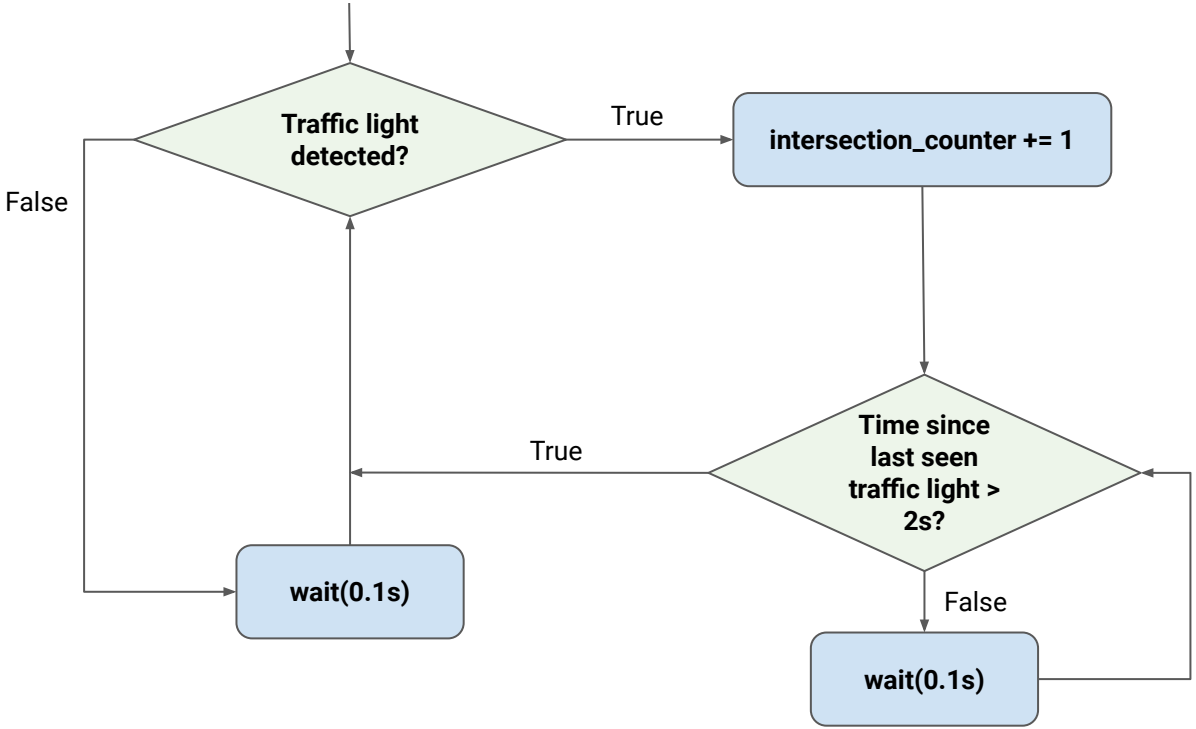
References

[1]: F. Codevilla, M. Müller, A. López, V. Koltun, and A. Dosovitskiy, “End-to-end driving via conditional imitation learning,” 2017. [Online]. Available: http://arxiv.org/abs/1710.02410

[2]: Ultralytics, 2023. [Website]. https://ultralytics.com/

Extra Slides

How the Navigation works.



Outlook