Building a Self-Driving Car

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Problem Statement

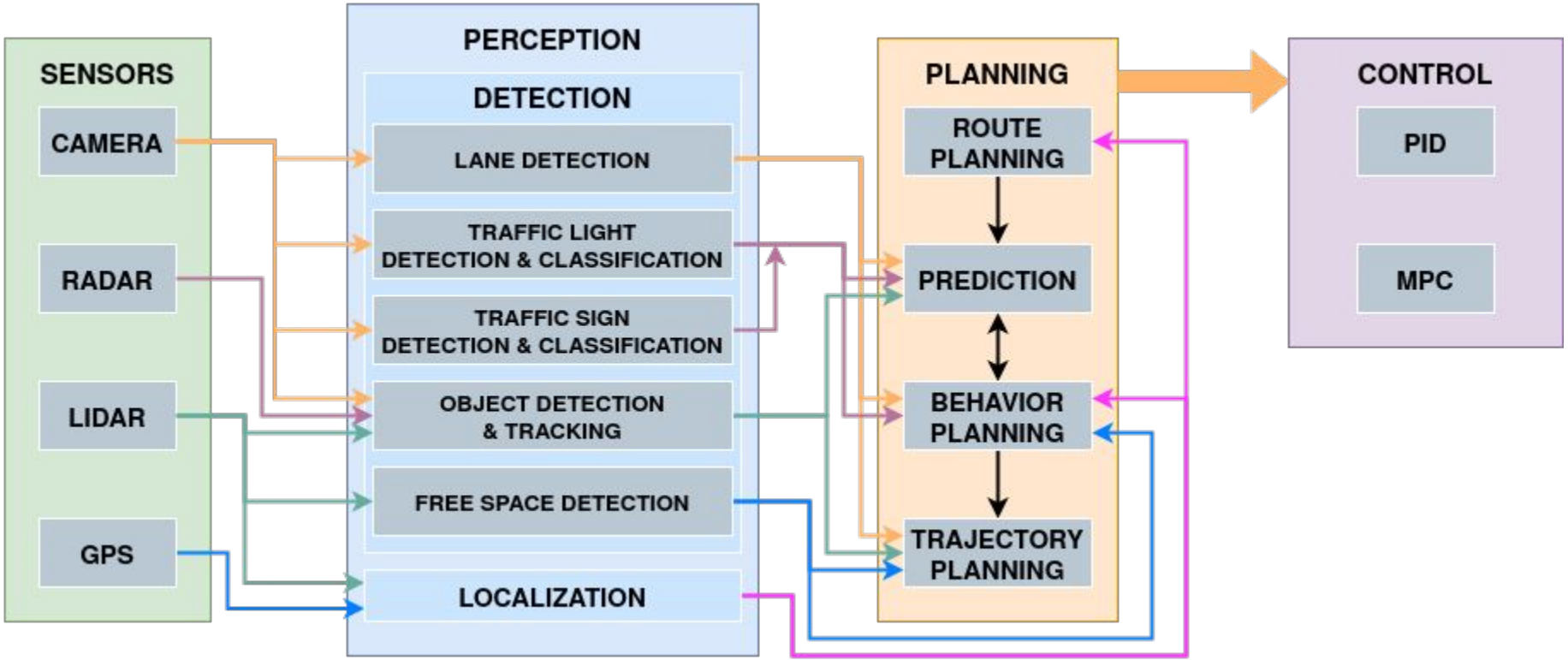
- ➔ More than 35k people die in auto accidents in the US each year*
- ➔ We need autonomous driving
- ➔ Apply computer vision, deep learning in practice
- ➔ Integrate related components to build a self driving car
- ➔ Test using Udacity Simulator

**National Highway Traffic Safety Administration, 2018*

Self driving cars

- ➔ A car that can guide itself without human conduction
- ➔ SAE defined levels of autonomy, level 0 to level 5
- ➔ Use various sensors, radars, lidars, cameras, machine learning for operation
- ➔ Leading companies Google, Tesla
- ➔ Two major components
  - ◆ Perception system
    - car localization, traffic light detection, obstacles detection, vehicle detection, road mapping, tracking, recognition
  - ◆ Decision making system
    - route planning, behavior selection, motion planning, obstacle avoidance and control

General Architecture



Project Description

- ➔ Implement the learned concepts to build a self driving car
- ➔ Sub systems built
1. Lane Detection
2. Traffic Light Classifier
3. Model predictive Control
4. Visual Odometry
5. ROS pipeline
- ➔ Test on Udacity simulator

Sub System 1- Lane Detection

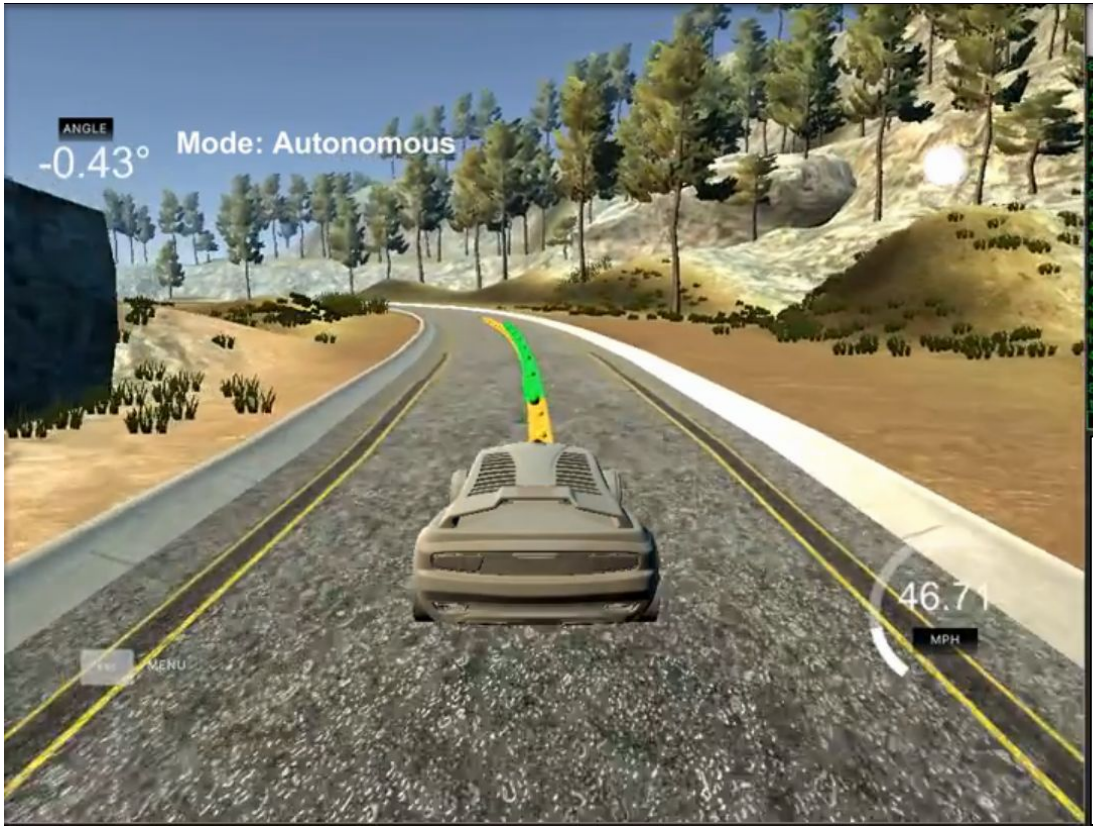
a. Basic lane detection
b. Advanced lane detection
c. SCNN lane detection, Deep learning based model

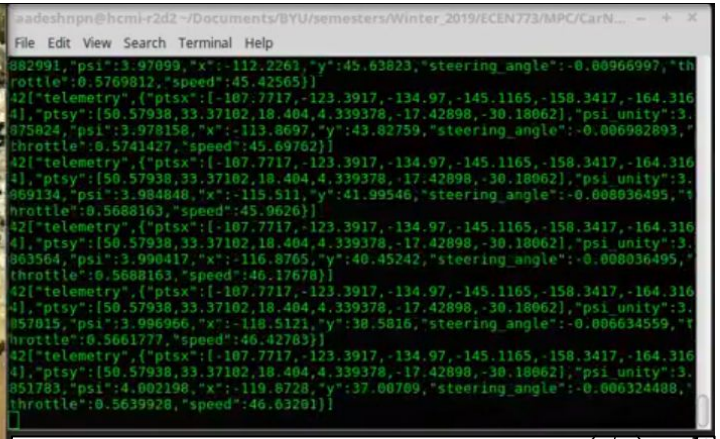
a) Basic Lane detection b) Advance Lane detection c) SCNN Lane detection

Sub System 2- Traffic Light Classification

- ➔ Trained Faster RCNN on Bosch Small Traffic lights dataset
  - ◆ Merged 15 class labels to just 4 labels, Green, Red, Yellow and Off

Sub System 3- MPC





$$x_{t+1} = x_t + v_t * cos(\psi_t) * dt$$

$$y_{t+1} = y_t + v_t * sin(\psi_t) * dt$$

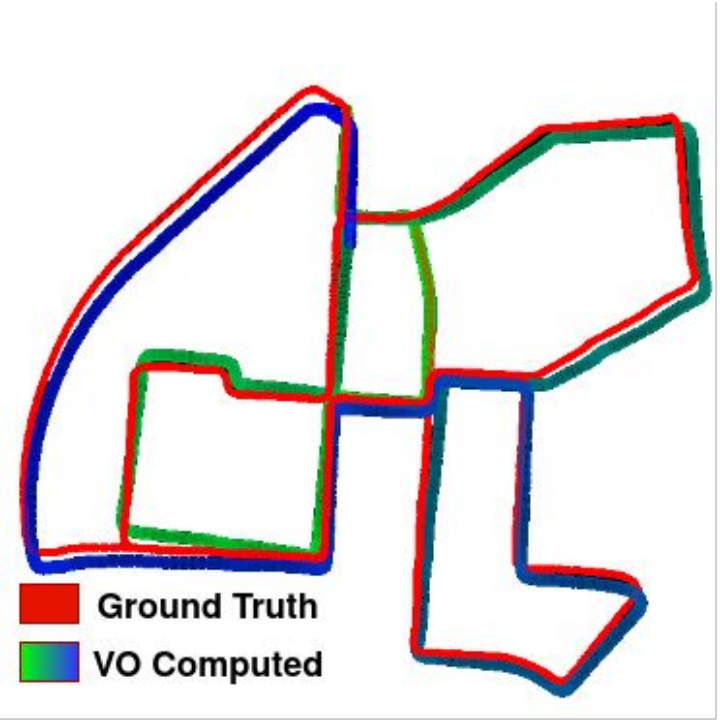
$$\psi_{t+1} = \psi_t + \frac{v_t}{L_f} * \delta_t * dt$$

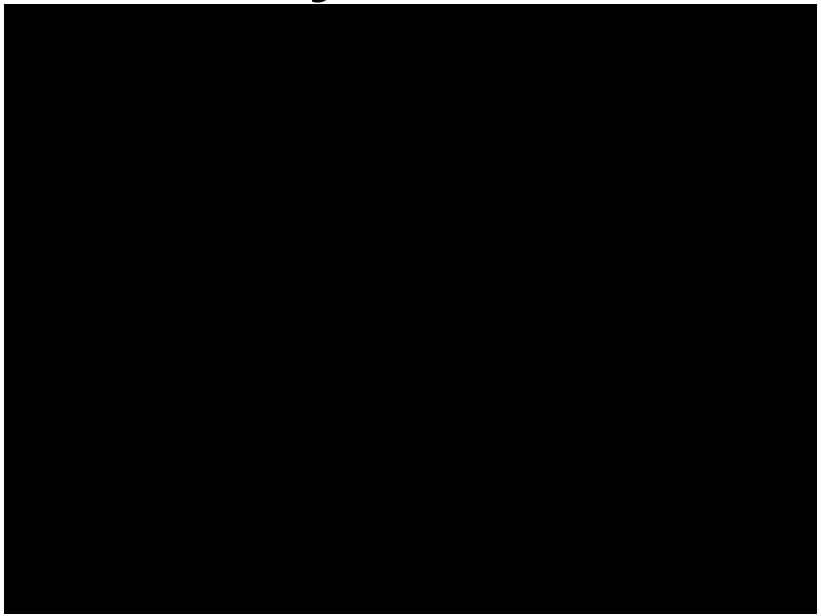
$$v_{t+1} = v_t + a_t * dt$$

$$cte_{t+1} = f(x_t) - y_t + (v_t * sin(e\psi_t) * dt)$$

$$e\psi_{t+1} = \psi_t - \psi des_t + \frac{v_t}{L_f} * \delta_t * dt$$

Sub System 3- Visual Odometry



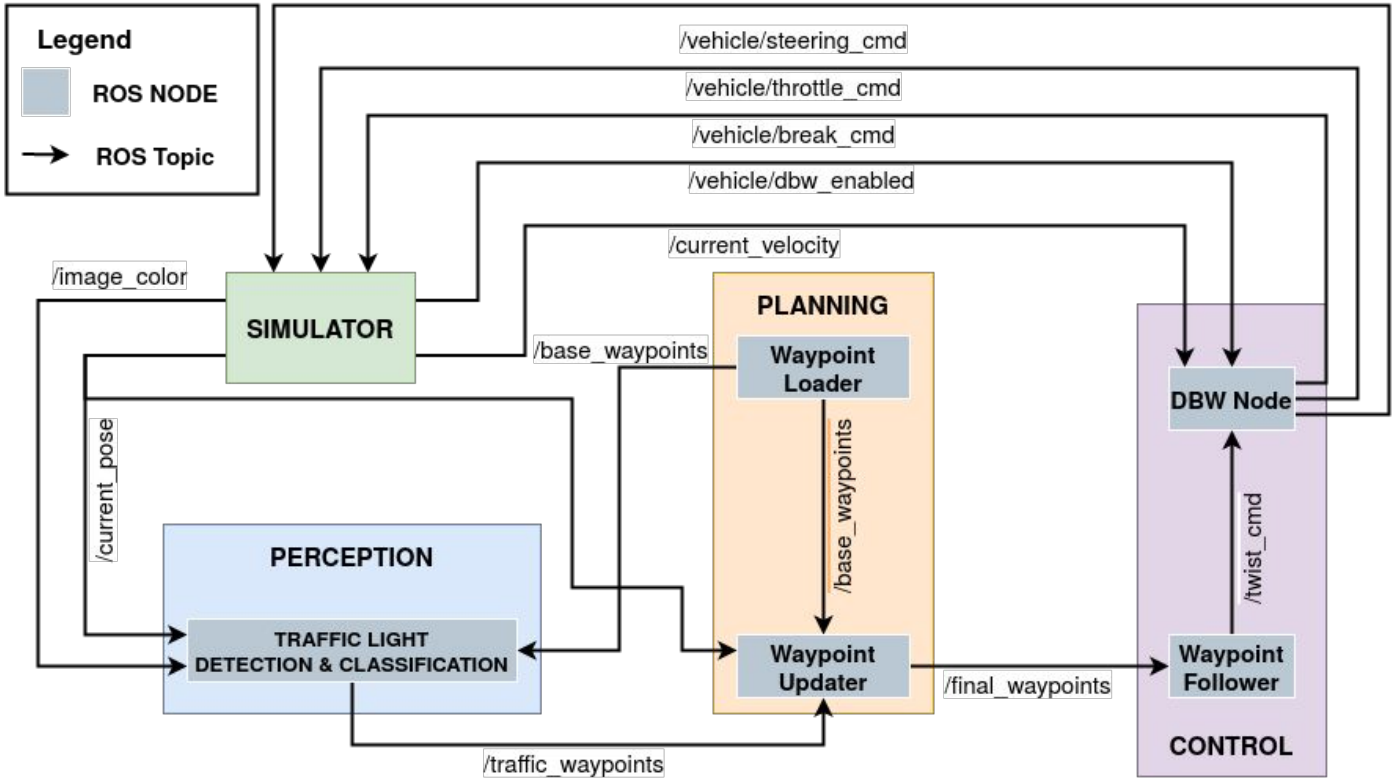


VO Pipeline

- Detect features using cv2.FastFeatureDetector
- Track features using cv2.calcCopticalFlowPyrLK
- Find essential matrix using cv2.findEsstentialMat
- Recover pose using cv2.recoverPose
- Update the current pose based on previous pose

Udacity Simulator

ROS Pipeline



Demo Video

Challenges

- Project setup with ROS Noetic and Python3
- Lagging of Traffic light detection module

Conclusion and Future work

Conclusion

- Explored and implemented core components of self-driving car
- A minimal working autonomous vehicle in simulation

Future Work

- Semantic segmentation to detect static and dynamic objects
- Remove lagging in the traffic detection module
- Use vSLAM instead of simulated provided waypoints for planning

Questions

Thank You!