GEM Pitch Presentation

LiDAR-Based Lane Detection
Team BobaBee

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10/15/2024

Problem Statement:

When using camera-based lane detection, problems such as lighting conditions, short ranges, and complicating computation of bird-eye-view transformation often make it difficult to precisely locate the lanes and adjust the parameters.

(a) Non Foggy Condition (b) Foggy Condition

Figure 1. Detection Difficulty during Adverse Weather

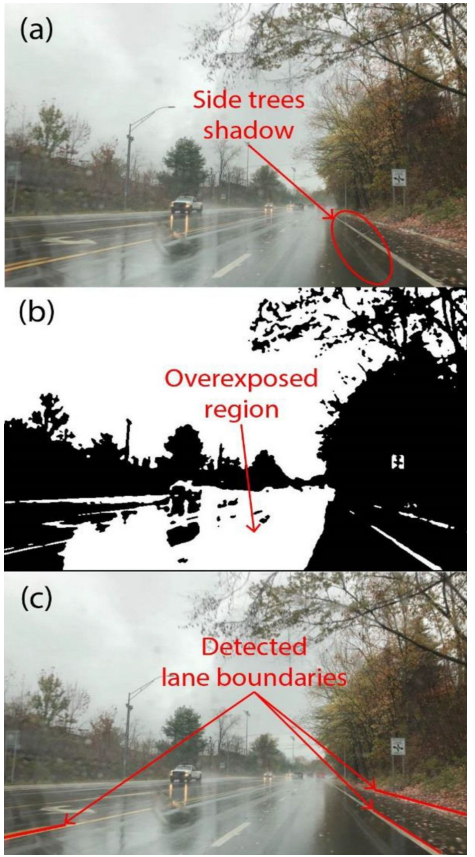


Figure 2. Detection Difficulty due to Lighting

Solution:

LiDAR-based lane detection is immune to these situations as LiDAR point cloud is not affected by lighting and weathers like rain and fog and has a longer range (100m). The main challenges of this solution are the filtering of point clouds and the choice of training model.

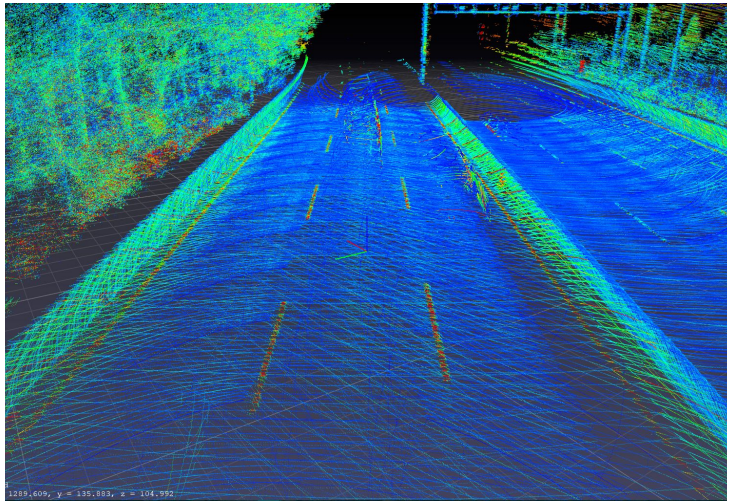


Figure 3. LiDAR Point Cloud

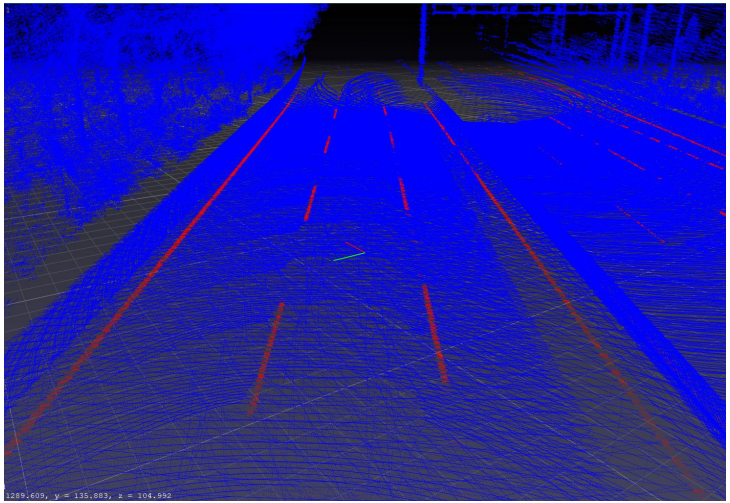
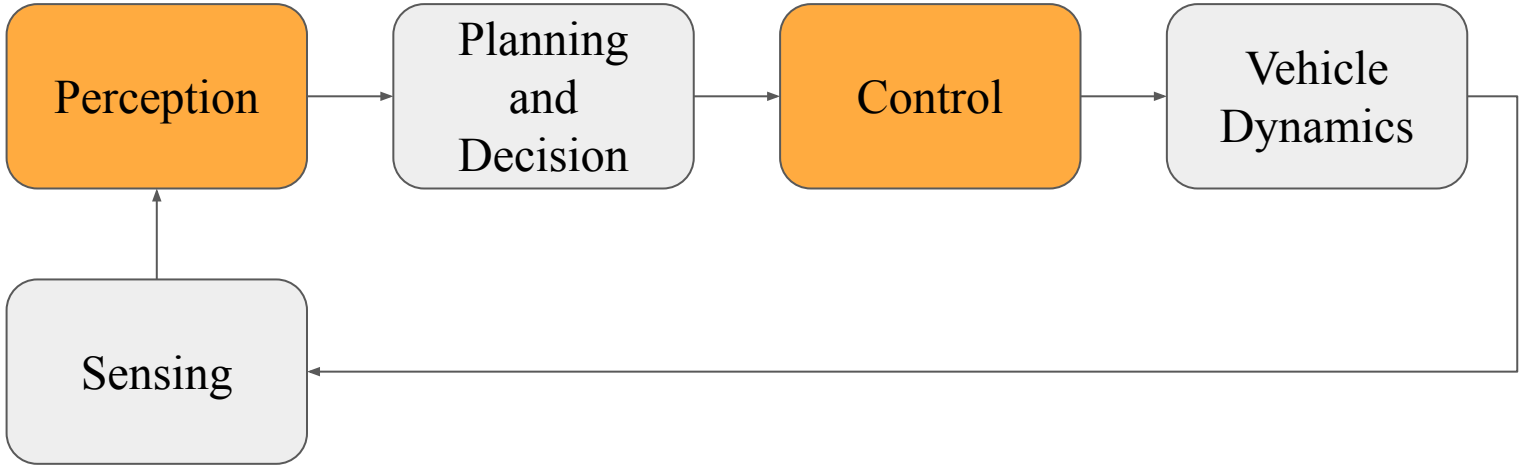
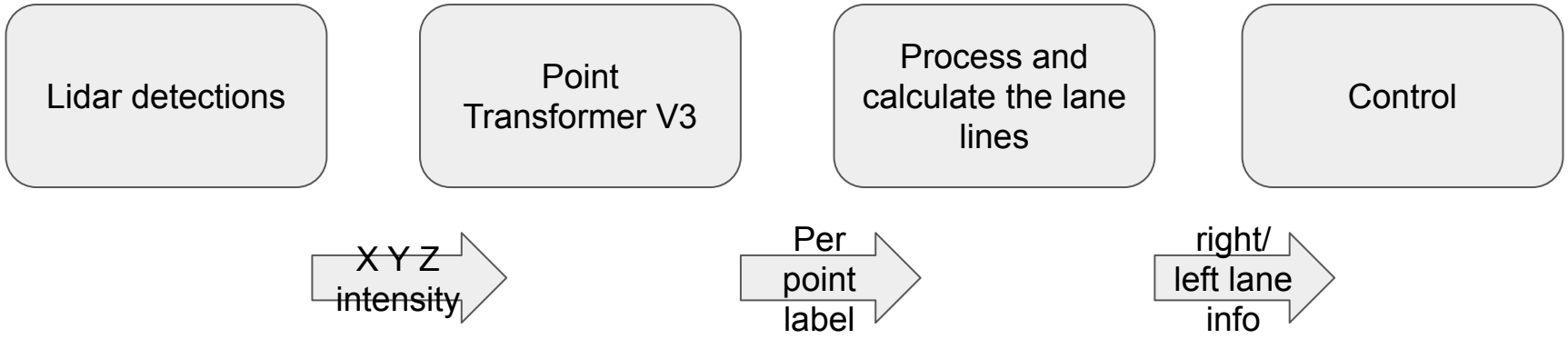


Figure 4. Labeling on Point Cloud

Plan and Preliminary Work

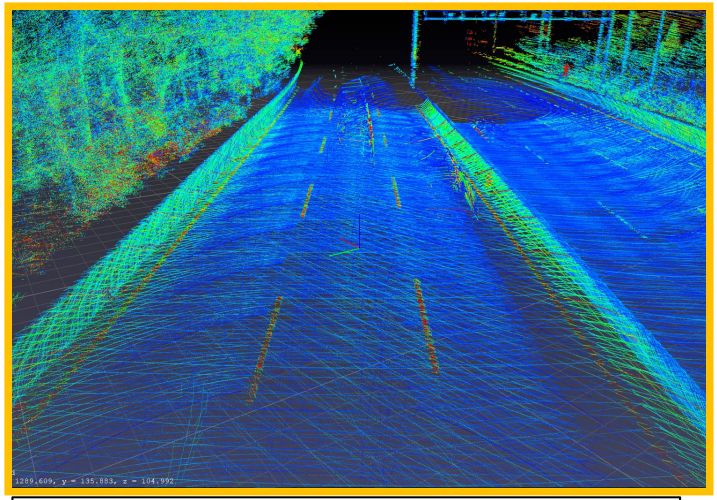


Plan and Preliminary Work

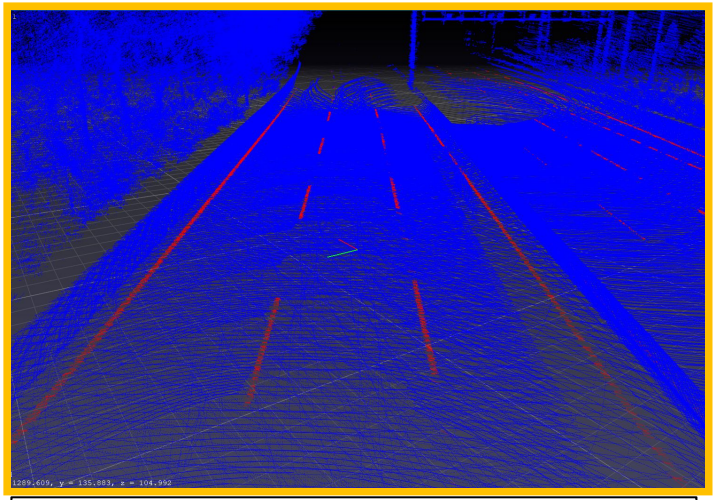


Plan and Preliminary Work - Point Transformer V3

Lidar detections → **Point Transformer V3** → Process and calculate the lane lines → Control



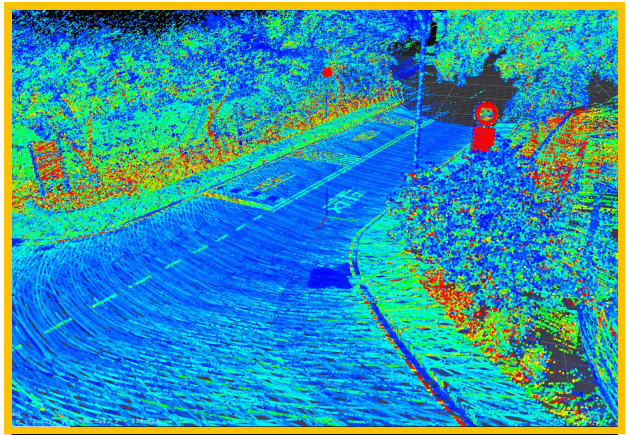
lidar point cloud with intensity



semantic labeling on lidar point cloud

Plan and Preliminary Work - Point Transformer V3

Lidar detections → **Point Transformer V3** → Process and calculate the lane lines → Control

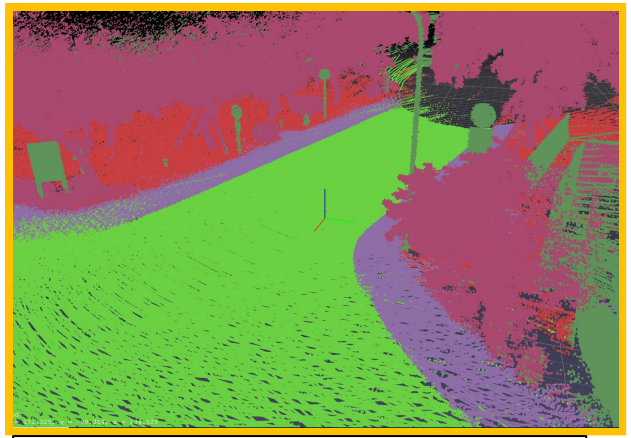


ITRI lidar point cloud with intensity

- remove the 64 layers to num_class segmentation head layer
- use the pre-trained nuscene model as the initial weight provided by PTv3 author [1]

Plan and Preliminary Work - Point Transformer V3

Lidar detections → **Point Transformer V3** → Process and calculate the lane lines → Control



ITRI lidar point cloud with semantic labeling

- remove the 64 layers to num_class segmentation head layer
- use the pre-trained nuscene model as the initial weight provided by PTv3 author [1]

Plan and Preliminary Work - Point Transformer V3

Lidar detections → **Point Transformer V3** → Process and calculate the lane lines → Control

Outdoor Efficiency (nuScenes)		Training		Inference	
Methods	Params.	Latency	Memory	Latency	Memory
MinkUNet / 3 [13]	37.9M	163ms	3.3G	48ms	1.7G
MinkUNet / 5 [13]	170.3M	455ms	5.6G	145ms	2.1G
MinkUNet / 7 [13]	465.0M	**1120ms**	12.4G	**337ms**	2.8G
PTv2 / 16 [90]	12.8M	213ms	10.3G	146ms	12.3G
PTv2 / 24 [90]	12.8M	308ms	17.6G	180ms	15.2G
PTv2 / 32 [90]	12.8M	354ms	**21.5G**	213ms	**19.4G**
PTv3 / 256 (ours)	46.2M	120ms	3.3G	44ms	1.2G
PTv3 / 1024 (ours)	46.2M	119ms	3.3G	44ms	1.2G
PTv3 / 4096 (ours)	46.2M	125ms	3.3G	45ms	1.2G

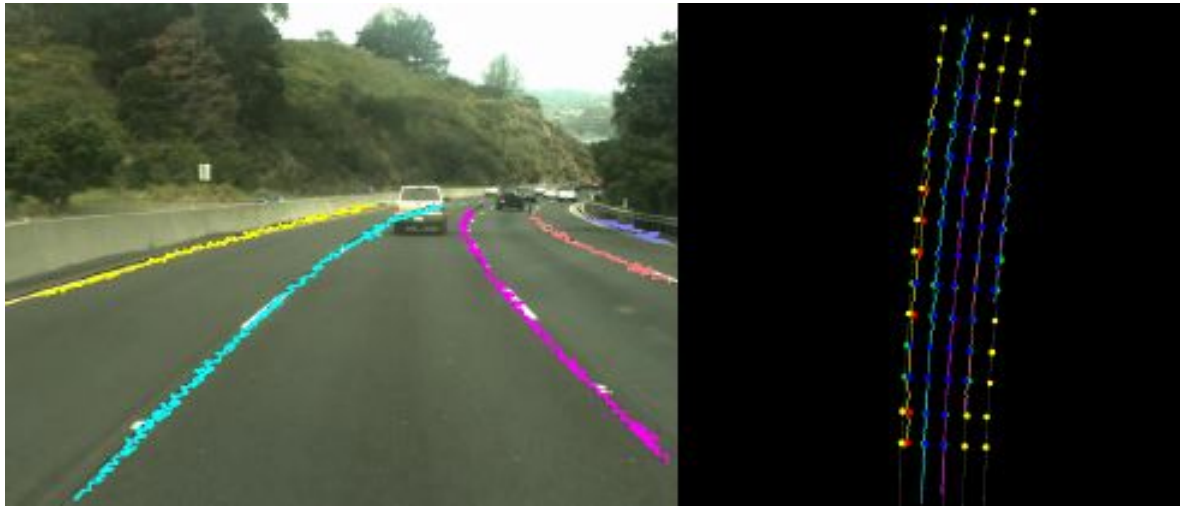
Plan and Preliminary Work

Lidar detections

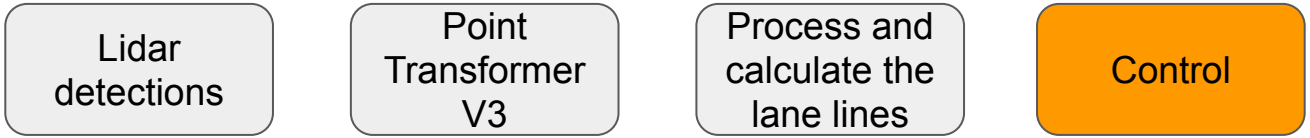
Point Transformer V3

Process and calculate the lane lines

Control



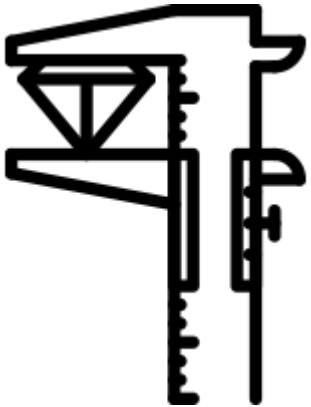
Plan and Preliminary Work



Similar to MPs,

1. Locate the vehicle position in Lidar frame
2. Select two lanes closest to the vehicle (one from right; one from left)
3. Adjust the steering angle according to the angle of the lane

Evaluation & Metrics



Key Metrics for Safety Evaluation

- Distance from Center of Lane
- Lane Departure Frequency
- Maximum Speed and Acceleration

Evaluation and Comparison

- We will evaluate our solution with respect to the performance of a camera-based lane detection system
- Initial Testing: Rosbag simulations
- Field Testing: Daytime and Nighttime Scenarios. Various Weather Conditions (Fog and/or Rain if Possible)

Challenges and Risks

- Effective Filtering Techniques: LiDAR data can contain a lot of noise, especially in certain environments, making it difficult to extract clean lane data.

Roles and Responsibilities

Name	Role	Responsibility
Kevin Huang	Perception	• Record rosbags for Lidar-Point Cloud • Develop algorithm to filter out the unnecessary points
Bryan Chang	Training Model	• Label the lane for training model • Implement and train the model
Steven YM Chang	Lane Detection	• Use the points labeled by the model to detect current lane the vehicle is on
Ian Bai	Control	• Develop the algorithm for controlling the vehicle to follow the current lane

References

[1] Wu, Xiaoyang, et al. "Point Transformer V3: Simpler, Faster, Stronger." *ArXiv*, 2023, https://arxiv.org/abs/2312.10035. Accessed 14 Oct. 2024.

Grading Plan

The project is an opportunity to learn and discover principles of safe autonomy, while building something cool. The following slides give you templates for 3 different types of projects. The templates lay out the first rungs, not the summit. Here are the aspects we will pay attention to as we evaluate your pitch presentation and later the project. Think of these as you plan; you **do not** have to answer these questions in your slide.

1. **Problem definition**: What problem are you solving? Why is it hard and interesting?
    a. Is the problem formulation detailed enough?
    b. Does the problem formulation show adequate understanding of the problem space?
    c. Appropriately ambitious?
2. **Approach**: How you plan to solve the problem?
    a. Do you understand the overall system and its various components?
    b. Which pieces are you going to modify and how?
    c. Preliminary work and progress so far
    d. What are the aspects of the approach that are most novel? Which aspects are easy
    e. Task allocation in group and plan for execution of the plan
3. **Test and evaluation**: What are the key metrics for evaluating the solution to your problem. E.g., time-to-collision is a metric for safety;
    a. How are you evaluating your solution with respect to your metrics?
    b. Are you simulating as well as performing field tests? Simulations?
    c. What are the different scenarios under which you are performing evaluation?
4. **Presentation**
    a. Design and organization of information
    b. Professionalism of presentation, delivery