BDD Project Progress Report

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Project Title: Real-Time Perception/Prediction of Traffic Scene with Deep Learning for Autonomous Driving

PI: Xiao-Yun Lu, PATH, ITS, UC Berkeley

Email: xiaoyun.lu@berkeley.edu  Tel: 510-665-3644;  Cell: 925-247-4493

1. Main Work

Use lidar data for real-time traffic scene detection of the following scenarios: (a) short distance cut-in; (b) other vehicle merging from onramp and conflicting with CACC Truck (Fig. 1); the software developed will be used in real-time for CACC; the code will be put in BDD Repository

Fig. 1. Two scenarios to be considered in this project: (a) other vehicle short distance cut-in; (2) other vehicle merging from onramp

2. Hardware Development

We choose to use Leddar for side target detection. Leddar a infrared lidar product of LeddarTech. The Features Leddar unit are listed below:

- 16 fixed beams
- Angle range for detection: 45 [deg]
- Angle between beams: 3 [deg]
- Distance detection for each beam: 50 [m]
- Highest data update rate: 100 [Hz]
Flexible multiple interfaces available
- Detection accuracy: 5 [cm]
- Distance resolution 10 [mm]
- Output data for each beam:
  - Time stamp
  - Target distance
  - Health status

Fig. 2 Left: Leddar unit; Middle: Fixed beam distribution; Right: detection scheme

We have installed two Leddar units on a Volvo truck and wire the two units with central control computer which running QNX as the Real-Time Operating System. The following Fig. 4 shows the hardware installation. The detection angle of the Leddar is shown in Figure 3.

Fig. 3. Installation of two Leddar units on front bumper of a Volvo truck

Software: we have developed the following software modules: (a) interface with the two Leddar units; (b) streamline real-time lidar data into the central PC-104 computer.
3. Detection and Target Tracking

The threat assessment is based on the target distance towards the truck moving direction. Since each Leddar unit has 16 beams, more than one (actually many) of them will detect part of the target – the body of the target vehicle as shown in Fig. 4.

We have collected Leddar data with the truck driven in middle lane on I-580 so that both Leddar units will catch certain targets.

The distances between the detection points on the target and the truck moving direction of the 16 beams are used as the basic measurements. Based on those distances, we conducted the following data fusion to generate a reasonable and reliable distance between the target and the truck for threat assessment the next step. The following approaches have been used:

- The minimum distance (of all the beams) to the truck moving direction
- The mean of the distances of all the beams
- The limited mean is the mean of those relevant of distances that are within certain threshold. The threshold could be chosen as the lane width (about 10 m), for example; otherwise, the beam will be ignored
- The harmonic mean of the distances of all the beams
• The Limited harmonic mean of those distances that are within certain threshold: the threshold could be chosen of the half of the lane width; otherwise, the beam will be ignored.

The following Fig. 5 ~7 depicts the fused five target distances with respect to the truck moving distance.

**Fig. 5** Comparison of all mean distances

**Fig. 6** Comparison of all mean distances, zoomed
4. **Next Step**

We will select and use the best fused distance data for threat assessment and integration with CACC truck driving on freeways with public traffic:

- Develop Threat Assessment capability based on the fused Leddar distance will be evaluated for all the 5 data fusion method to find a best candidate;
- Determine any potential conflict between the target vehicle and the truck in the following two scenarios: (a) short distance cut-in; and (b) onramp merging;
- Input such information to CACC to handle those dangerous situations to improve safety.

We will write a Final Report to document all the finding for this research afterwards.