ILR #5: Progress Review 4

Zihao (Theo) Zhang- Team A

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Individual Progress

The team has been making progress on the physical mounting structure, the cameras, as well as the radar during the week of November 14th and 21st. In terms of individual work, I contributed most of my time on the physical mounting structure and tasks related to the radar.

With our team's testing vehicle arrived and the increasing need of more on-vehicle testing for both the cameras and radar, we finished integrating the sensors with the testing vehicle by the last weekend. I helped design/fabricate the new camera mounting structure and helped install both cameras and the radar on the testing vehicle.

Considering other crucial tasks that demanded more progress and the amount of time already consumed in designing and fabricating the water-proof camera housing, the team finally decided to pursue a different plan from our initial mounting solution: instead of fixing both cameras on the mounting rack above the roof of the testing vehicle, the cameras are now fixed in front of the windshield inside the vehicle. More specifically, the current camera fixture is composed of two side supports and an 80/20 aluminum beam. In need of a quick fabrication of the product, the initial prototype of the supports was made of wood. The material might need to be changed later in order to further increase the strength of the supports. They were installed on the testing vehicle at the location where the two sun visors were originally attached to the vehicle. Therefore, both sun visors and their fixture were removed in advance. The cameras are rigidly attached on the 80/20 beam hung over the dashboard by the two supports. The picture below demonstrates the on-board setup of the cameras that is illustrated above:

Figure 1. On-board setup of the cameras

Note that the current mounting structure of the cameras is paced inside the vehicle, it eliminates the need of developing a more advanced weather-proof camera housing while still satisfying the weather-proof requirement of our perception system at the same time.

As for the on-board setup of the Delphi ESR radar, it is mounted in front of the vehicle's grille which is about 50 centimeters above the ground, with a lateral offset about 20 centimeters from the vehicle centerline. Recalling from the Delphi ESR user manual that the radar's mounting location should be between 300 mm and 860 mm from the road surface, we figured out that the current mounting location would be the most ideal one after taking the front exterior of the testing vehicle for reference as well. The picture below demonstrates the on-board setup of the radar that is illustrated above:

Figure 2. On-board setup of the radar

In order to conduct the on-road testing in a timely manner, the radar has been mounted on the testing vehicle using the zip ties as the temporary solution. Even though the zip ties have proved its rigidity after being used to fix the radar on the vehicle for an extended period of time, a more formal mounting method is still desired. Therefore, a new fixture for the radar was designed recently, and its CAD model is shown as the following:

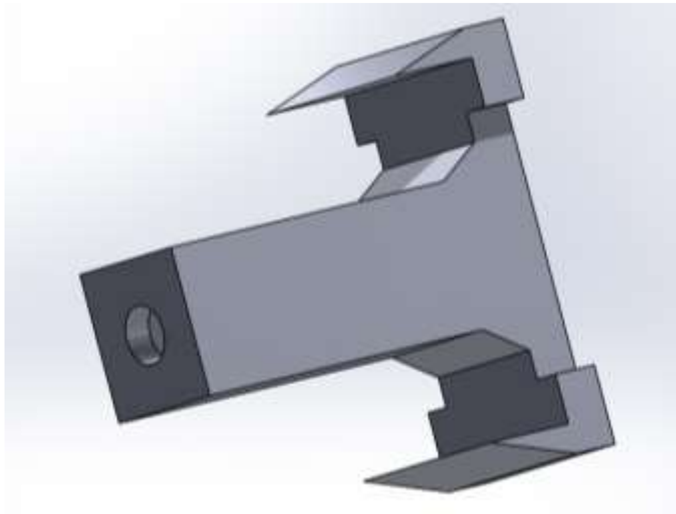

Figure 3. New fixture design for the radar

The fixture shown above can be inserted into the vehicle grille. The two hooks on the fixture shall be able to clamp the fixture to the grille from the back. The radar can be then attached rigidly with the fixture using the M6 screw and nut so that it is also attached rigidly with respect to the grille and the vehicle. Because there are three mounting holes on the Delphi ESR radar, three individual fixtures will be used to attach the radar to the vehicle.

After both the cameras and the radar was set up properly on the vehicle, I conducted the on-road testing of the radar. The real-time data from the radar (spatial information of each detected target) was visualized in a 3D map using the PolySync Studio. The on-road testing scenario was demonstrated in the following picture:

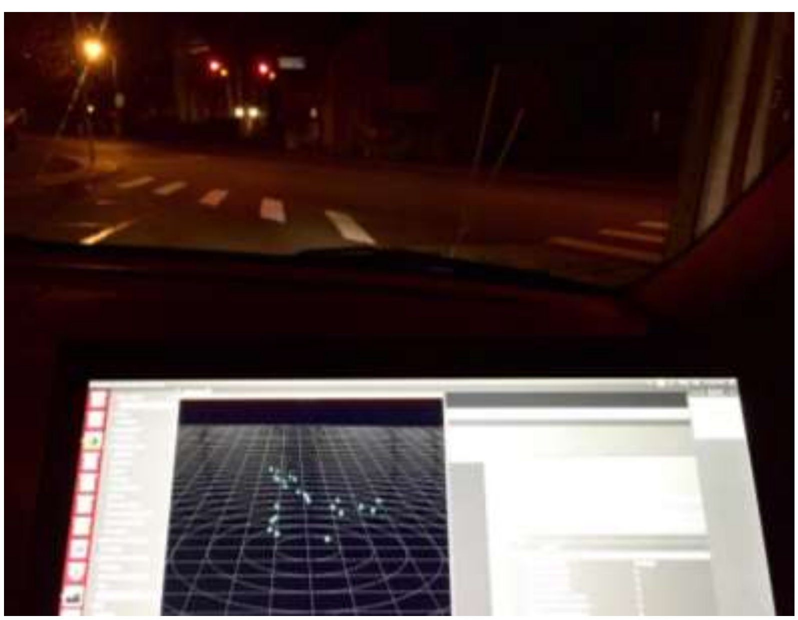

Figure 4. On-road testing of Delphi ESR radar

During the on-road testing, I was also able to validate my earlier assumption based on the literature review on the Delphi ESR radar that the raw data from the radar was segmented and pre-clustered into up to 64 groups or "targets". So each point that the user would perceive directly from the computer represents a tracking target.

The on-road testing data was also recorded for further analysis. By exploring the documentation of PolySync API online, I was able to extract useful information of each target detected by the radar from the recorded data, such as the tracking status, the x-y-z position, and the range/ range rate of each target.

Challenges

The primary challenge that I've been encountered during the past weeks was about handling and manipulating the data from the radar. This is mainly due to the team's limited familiarity with PolySync API. Since the PolySync Studio that has been currently used is only for direct 3D visualization of the radar data, developing our own software applications on the PolySync platform was still required in order to interact the data from the radar with the data from the cameras. Therefore, I have started to build more knowledge on the software architecture and data model of PolySync through its online documentation, as well as more knowledge in the C++ programming in order to accelerate the development process of our own software applications.

Moreover, we investigated during the on-road testing that the data from the radar actually contained many noisy points that would not be useful at all for our desired perception tasks. Therefore, some algorithms need to be developed and applied later in order to filter out the noisy detected points and keep only the targets useful to our tasks.

Teamwork

Amit Agarwal:

Amit has been in charge of maintaining communications between our team and PolySync, the provider of the middleware platform that we are currently using for the Delphi ESR radar. He also helped with interpretation of the recorded data from the on-road testing of the radar.

Harry Golash:

Harry worked on designing and fabricating the new camera mounting structure inside our testing vehicle. He also helped install all sensors on the testing vehicle. He served as the driver during the outdoor (on-road) testing.

Harry also developed the software program for triggering both cameras for the stereo vision system.

Yihao Qian:

Yihao also worked together with me and Harry on the sensor installation on the testing vehicle. He participated in the on-road testing and was in charge of testing the object detection algorithm using real-time data from the cameras.

He also did research on building the stereo vision system using two cameras and have started on the implementation using MATLAB.

Menghan Zhang:

Menghan worked mostly on getting more familiar with the Single Shot MultiBox Detector (SSD) algorithm through research papers and other open resources. She has also started the implementation of the SSD algorithm in order to make it functional on our own devices.

Plans

Our next project milestone is the Fall Validation Experiment (FVE). As scheduled already for the Fall Validation Experiment, our team would like to achieve the following goals on our project of developing the perception system using Stereo Vision and radar:

1. Verifying robustness of sensor rack and mounting method

2. Verifying stereo vision performance in adverse weather conditions

3. Verifying sensor synchronization

4. Testing the accuracy of the object detection algorithm

5. Completing fabrication of the power distribution PCB and making it functional

In term of individual work, I will be mainly involved in tasks related to the radar and the power distribution PCB (Task 1, Task 3, and Task 5).

Specifically, I'll be primarily in charge of testing/ improving the mounting method for the radar, manipulating data from the radar to interact with data from the cameras, and fabricating/ testing the printed circuit board.