ILR #2: Progress Review 1

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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 October 16th. In terms of individual work, I contributed most of my time on the cameras and radar.

First of all, I assembled our two Grasshoppers 3 cameras from Point Grey, as the sensors and lenses were purchased and shipped separately. Together with Yihao, I set up and tested both cameras by connecting them with a laptop computer. Since this was our very first testing on the cameras, the objective was set to be relatively simple, which was just to prove the basic functionality of both cameras. By using the FlyCapture2 Viewer downloaded from Point Grey's website as the user interface, we successfully received image data from both cameras and were able to record the data for certain periods of time. Noting that this Viewer package is only a "minimal installer" for basic demo applications as described on Point Grey's website, its functionality is too limited to support tasks that we would like to achieve on the cameras for our project, such as synchronization between the cameras as well as scene integration for our stereo vision system. Therefore, the FlyCapture2 Full SDK package will be installed and used to develop applications for these tasks in the future.

In addition, I conducted a literature review on the Delphi ESR 2.5 radar that was provided for our project. Although time consuming, such a background research was very crucial from my perspective, as none of our team members had had much experience on this specific type of radar. Operating the radar without sufficient knowledge would also increase the risk of causing unnecessary damage to the expensive sensor.

Among all resources I collected, I chose to focus on two paper publications [1] [2] and one academic report [3] with the most relevance; all these three documents involved either detailed performance analysis or extensive use of the same model of radar (Delphi ESR) that we would use for our project. Some important findings and key points from these documents are summarized as the following:

- The Delphi Electronically Scanning Radar (ESR) is commonly recognized as one of the most advanced and cost-effective radar for automotive related applications, with a 99.995% detection rate on cars up to 180 meters ahead [1].
- Unlike traditional radar models that required manual segmentation and clustering of raw data points from detection, the Delphi ESR would be able to "directly" provide information of detected targets [2]. The radar can detect up to 64 targets in both mid-range (60 meters) and long range (174 meters) simultaneously [3].
- In principle, the Delphi ESR has the ability to classify objects based on different powers of signal reflected from detected objects. However, its performance did not seem reliable

during the real world testing [1]. This implied that we shall still reply mostly on visual information from cameras for the object classification task.

- "Delphi manual specifies that the radar should be between 30 cm and 86 cm above the ground when mounted on the front of a car" [1]. Since we planned to fix the cameras on the roof rack of the testing vehicle (> 150 cm), the radar may have to be mounted at a separate location.
- Like most other electronics on automobile, the Delphi ESR uses Controller Area Network (CAN) bus standard for data transmission. This means "accessing the data it produces requires hardware that can interface between the CAN bus standard and the common interfaces used by modern computers" [3]. In addition, the Private CAN Serial communication specification from Delphi might be needed in order to decode detection data from the radar [3].

However, a detailed instruction on how to set up the Delphi ESR properly with computer had not been discovered yet.

Challenges

We have encountered tough challenges while trying to make progress on the Delphi ESR 2.5 radar. First of all, this is because no one from our team had previous experience on this type of radar. Secondly, we have not received any response from our sponsor since the last request for more information on the radar. Moreover, because the Delphi ESR radar is a relatively new product in the market and is specifically designed for use in automobiles, its state-of-the-art technology as well as limited field of applications both result in limited resources we could potentially find in the literature. In addition, the fact that many of these resources are considered as confidential by the manufacturers further adds the difficulty to find any useful information (even the user manual) on the Internet.

Regarding instructions on setting up the communication between the Delphi ESR and computer, it has been discovered that "a custom Robotic Operating System (ROS) driver" might be capable of interfacing the CAN communication [1]. In addition, the *sicktoolbox_wrapper* and *rviz* packages in ROS could be used for processing and visualizing data from the radar. Nevertheless, such information still remains abstract during actual implementations.

Therefore, receiving information and proper guidance from our sponsor would still be the most feasible way to solve the current problem.

Teamwork

Major job duties of my teammates:

Amit Agarwal	Designed the camera housing prototype
Harry Golash	Designed and fabricated the camera housing prototype
Yihao Qian	Tested cameras and explored FlyCapture2 SDK
Menghan Zhang	Updated team's website

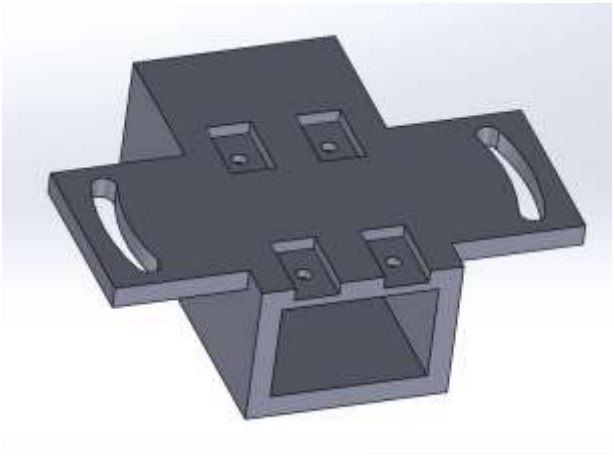

Figure 1. CAD design of the camera housing

Figure 2. 3D-printed prototype of the camera housing

Plans

Before the next ILR/ progress review, our team would like to achieve the following goals on our project of developing the perception system using Stereo Vision and radar:

On the system level, we would like to:

1. Finish our Work Breakdown Structure (WBS) and an updated schedule
2. Choose appropriate platform for data processing
3. Start build the power distribution system for the sensors

For the two cameras, we would like to:

1. Finish the prototype of the weather-proof camera housing
2. Install FlyCapture2 Full SDK and explore the features
3. Utilize the GPIO pins to enable pulse trigger for camera synchronization

For the radar, we would like to wait until we receive and familiarize with all the necessary documentations (user manual etc.) and tools (software drivers etc.) for the proper setup in order to avoid any unnecessary damage to the radar.

I will keep collecting useful information about our Delphi ESR radar and will work on its setup once the team receive the documentations and tools. But until then, I will spend a little more time on helping make progress on the cameras. I am planning to learn more about the FlyCapture2 SDK and anything to prepare us for the upcoming camera synchronization task.

References

[1] Stanislas, Leo, and Thierry Peynot. "Characterisation of the Delphi Electronically Scanning Radar for robotics applications." (2015).

[2] Wang, Tao et al. “Integrating Millimeter Wave Radar with a Monocular Vision Sensor for On-Road Obstacle Detection Applications.” *Sensors (Basel, Switzerland)* 11.9 (2011): 8992–9008.*PMC*. Web. 22 Oct. 2016.

[3] Parikh, Gordon, and John Hourdos. “Implementation of High Accuracy Radar Detectors For Traffic Safety Countermeasure Evaluation.” Tech. Center for Transportation Studies, University of Minnesota. Jun. 2014.