ILR #11: Progress Review 12

Zihao (Theo) Zhang- Team A

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Individual Progress

Since the last progress review, I have continued to facilitate progress on the system integration in ROS. The comparison between the following two figures serves as a straightforward way to show our progress on system integration during the past one and half weeks.

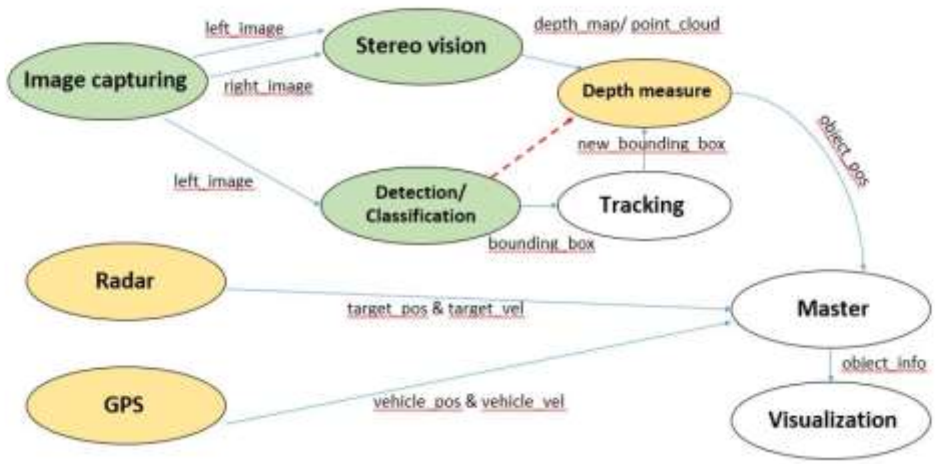

Figure 1. System integration status by Progress Review 11

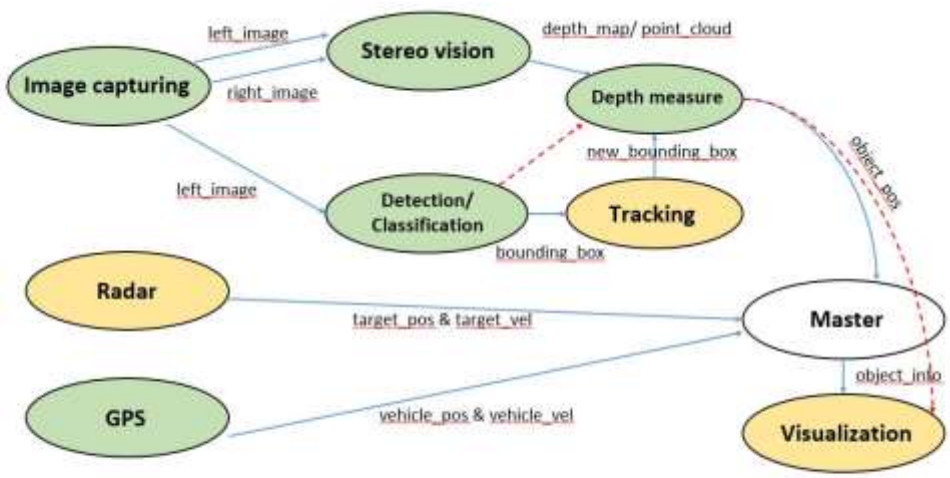

Figure 2. System integration status by Progress Review 12

First of all, I have finished connecting our GPS module to ROS. I decided to use the *nmea_navsat_driver* package, which takes unprocessed NMEA sentences from the GPS at serial port and parses the data into useful position (longitude + latitude) and velocity information.

Currently, the information from GPS can be published in ROS successfully. It is yet to be integrated with the rest of the system, as we still need to first finish building our master/ fusion node, which will subscribe the messages from the GPS.

For the vision subsystem, I have been working with Yihao and Menghan to achieve decent progress. Along our planned pipeline as shown in the figure 2 above, we have finished building and connecting the image capturing node, the stereo vision node, the detection and classification node, and the depth measure node by this progress review. By bypassing the unfinished master node (for planned data fusion with radar later), we took the shortcut to directly connect the depth measure node to the Rviz, which serves as our visualization node.

By the last progress review, we were able to publish the depth information of each detected object by subscribing and synchronizing the messages from both the stereo vision node (elas_ros) and the detection and classification node (ssd). However, we realized a few problems after obtaining the intermediate result. Specifically,

1. We noticed the slow update rate of depth /disparity map (~1 Hz) by the ELAS node, which became a serious bottleneck to prevent our system from operating towards real time.
2. The quality of the disparity maps generated by the ELAS ROS package was far from satisfying, while the depth map generated by the package did not make much sense through visualization using Rviz.
3. Even with the depth information, additional calculations still needed to be done in the depth measure node in order to get the objects' 2D positions (both longitudinally and laterally) visualized.

To address the problems mentioned above, I tested the SGBM (Semi-global block matching) algorithm on ROS as an alternative to the ELAS algorithm. By comparing the overall performance of the two algorithms/ nodes, I noticed that the SGBM could be performed more efficiently (with higher update rate) on ROS. One possible reason was that the SGBM was included as a nodelet in the *stereo_image_proc* package. Therefore, it can be run with the image rectification in a single process without any unnecessary message transformation in between. In contrast, the ELAS ROS node was implemented as a wrapper to the LIBELAS library, which might cause relatively longer processing time.

To reduce as many sources of error as possible, I redid the stereo camera calibration with Yihao. We re-adjusted the baseline and the camera positions and updated the new camera matrices in ROS.

To work with the SGBM ROS node, I modified and restructured the depth measure node to subscribe to the *disparity* messages (instead of the *depth* messages) from the SGBM, transform the disparity messages into proper message type so that it could be processed using OpenCV functions. I took advantage of the *reprojectImageTo3D* function from OpenCV, which could re-project a disparity image to 3D space. In our customized depth measure node, we searched and collected all valid position values associated with all pixel coordinates inside the provided bounding box of the detected object(s). We finally took the median of all the valid position values to be the position assigned to the detect object(s).

At the current stage, our depth measure node can be used to detect multiple human objects or cars in each single frame. The position information (with reasonable values) of each detected object can be published to Rviz and clearly visualized in a 2D grid from the top-down view.

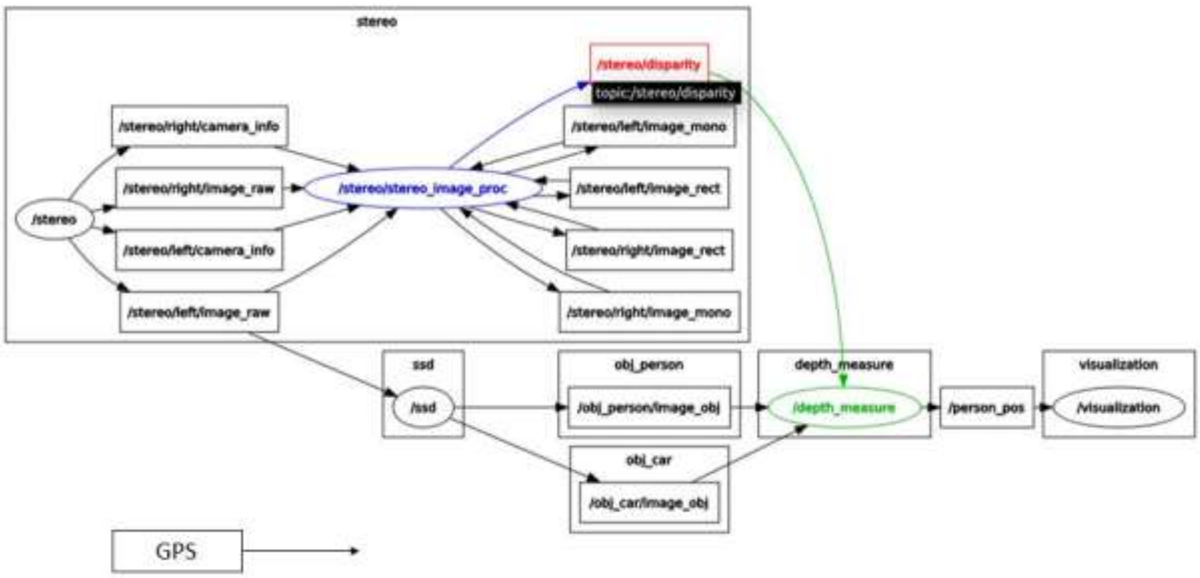

Figure 3. Current system architecture in ROS

Challenges

The fact that the team was unable to perform a dress rehearsal of SVE during this progress review reflects the great challenges we are facing.

In contrast to the consistent progress on the vision subsystem, the stagnation on the radar has been no doubt the biggest challenge. It becomes an extremely serious problem, especially given the extremely limited time away from the Spring Validation Experiment. I will try my best to urge the teammates who are in charge of the work on the radar to provide a decent result on the radar by the Spring Validation Experiment and meanwhile offer some help to facilitate the progress on the radar as well.

On the vision side, the relatively slow processing speed of the stereo vision algorithm becomes a bottleneck to the update rate of the disparity map and therefore the objects' positions. This would make getting the accurate/meaningful objects' velocity information extremely difficult solely based on the vision subsystem. We will re-evaluate the feasibility of achieving object tracking with velocity information using either the radar or stereo vision within the future one week before SVE and will consider further descoping on the project if necessary.

Teamwork

Amit Agarwal:

Amit has been in charge of the work on the radar with Harry. They have not shown any new progress on the radar since the last progress review and were unable to show the progress during the last progress review due to the missing code for basic visualization of the radar detection data.

Harry Golash:

Harry has been in charge of the work on the radar with Amit. They have not shown any new progress on the radar since the last progress review and were unable to show the progress during the last progress review due to the missing code for basic visualization of the radar detection data.

Yihao Qian:

Yihao has been working with me and Menghan on the system integration. He helped with the re-calibration on the stereo cameras, as well as the debugging and testing of our new stereo vison and depth measure nodes on ROS.

Menghan Zhang:

Menghan has been working on building the tracking module for our system on ROS. Besides, she finished building the preliminary visualization node for our system so that the position information of each detected object published by the depth measure node could be displayed in Rviz for demonstration during this progress review.

Plans

Before the Spring Validation Experiment (SVE) on April 26th, our team would like to achieve the following goals on our project of developing the perception system using Stereo Vision and radar:

1. Overlay of radar and stereo vision data
2. Completed system architecture in ROS
3. All sensors and power devices properly mounted/ placed on the testing vehicle
4. Velocity information through object tracking by the radar if possible.

In terms of individual work plan, I will conduct more testing on the stereo vision node to see if there's any space to further improve either the processing speed of the algorithm or the quality of the disparity map. I will wrap up all current work for the vision subsystem and provide as much help as I can on radar filtering before the Spring Validation Experiment next week.