Automated Driving Using External Perception

Individual Lab Report - ILR04

March 23, 2023

Team E - Outersense

Author:

Dhanesh Pamnani

Team Members:

Atharv Pulapaka

Ronit Hire

Jash Shah

Shreyas Jha

Contents

1 Individual Progress

1.1 Making the infrastructure hardware Robust

For this progress review I worked on the Making the infrastructure units robust and the RGB calibration of the camera. The final cantilever shown in Figure 1 had all the basic features but had the problem of vibrations. To make the cantilever stable we added dead weight and trusses to the support. The aim for this PR was to get the manufacturing work complete. We faced various challenges which have been highlighted in the section below. The Figure 2 shows the CAD and manufactured infrastructure unit.

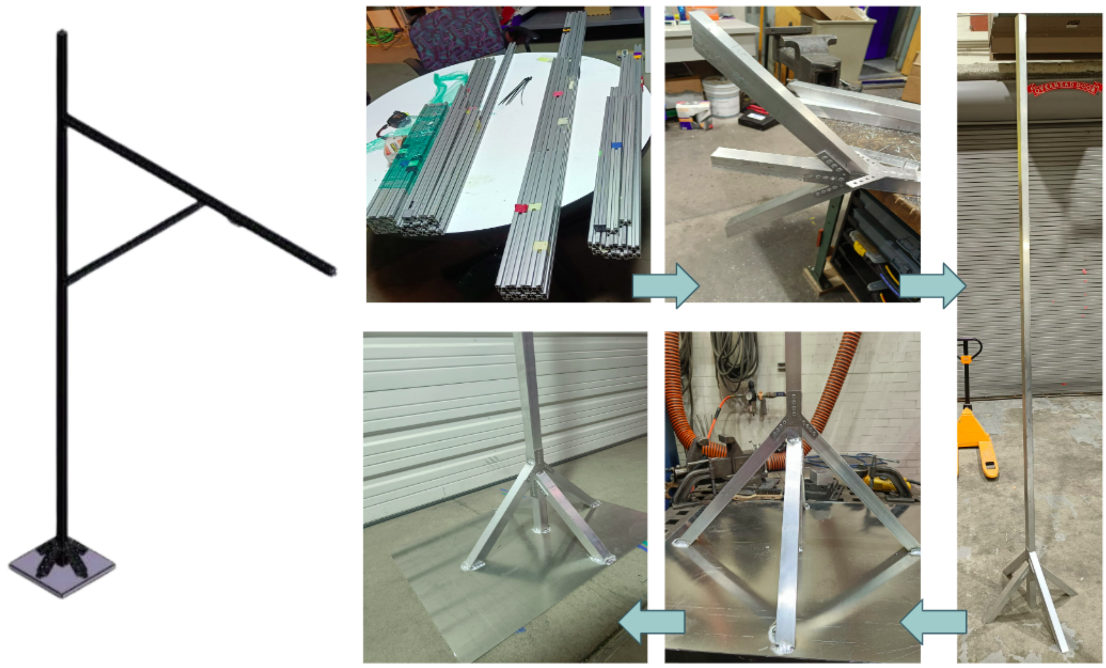

Figure 1: Basic Components of the Infrastructure

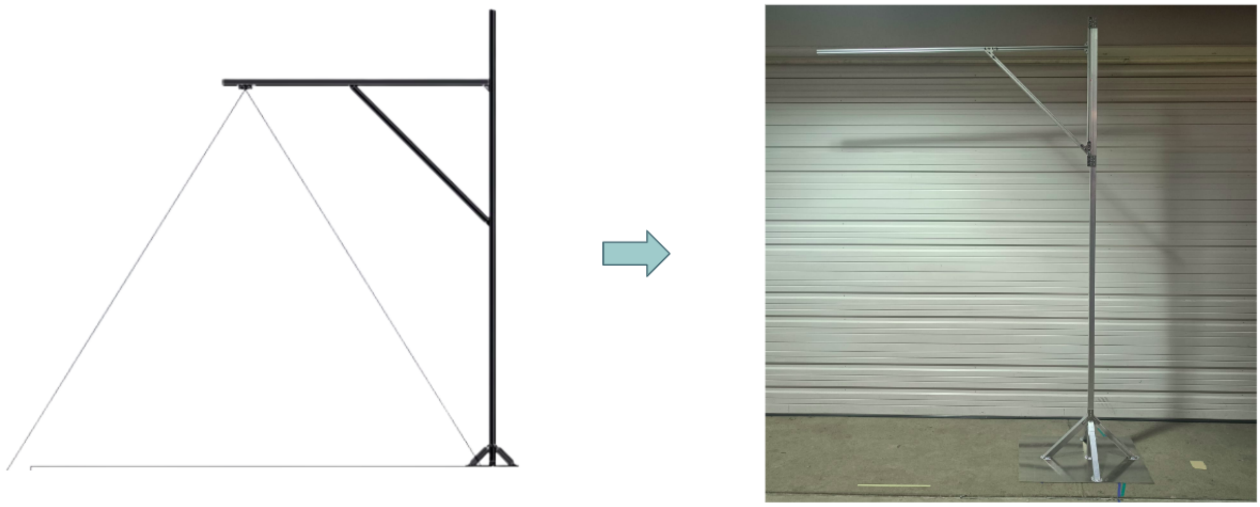

Figure 2: CAD and manufactured unit

1.2 Realsense D435i RGB Calibration

Calibration of Realsense is much trickier than it looks at first glance. The cameras come calibrated from the industry and there are various tools by Intel to calibrate the camera. Firstly, the d435i has 2 cameras the stereo depth and the RGB. The FOV and focal length for both are different. The depth cameras can be calibrated and validated using the Intel tools, however calibration of the RGB is not robust. This can be seen by the obtained re-projection errors. Further, Realsense does some undistorting to the image and then sends the frame, which further adds to the confusion of intrinsic calibration of RGB camera. The conclusion is using OpenCV tools to calibrate the camera. To add to the challenge writing to the camera is difficult and the calibration obtained through ROS is completely different. I performed the calibration using chessboard of known dimensions and followed the steps as provided by OpenCV. However the re-projection error after the un-distorting was more than that before it. This hinted towards a pre-processing that has already been done by the Realsense camera. I validated the extrinsic obtained by obtaining the distance of known points in the real world. The results obtained were not satisfactory. The Figure 3 is one of the chessboard figure used to calibrate the camera and obtain the intrinsic and extrinsic. It is important to note that OpenCV optimises the intrinsic, what that means is that the intrinsic obtained by Realsense and by OpenCv may not be the same. Further ROS uses OpenCV to calibrate the camera.

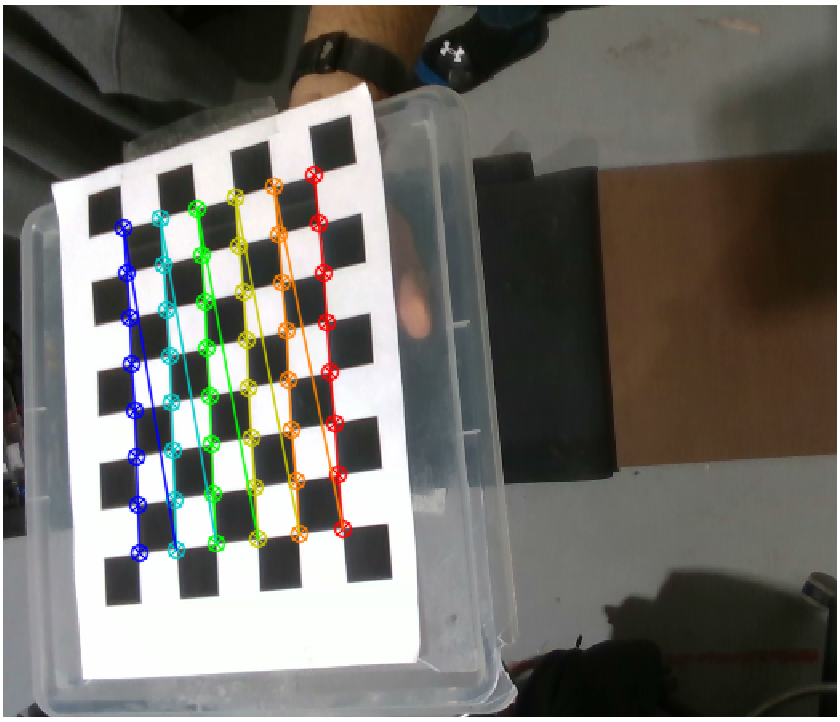

Figure 3: Chessboard figure used

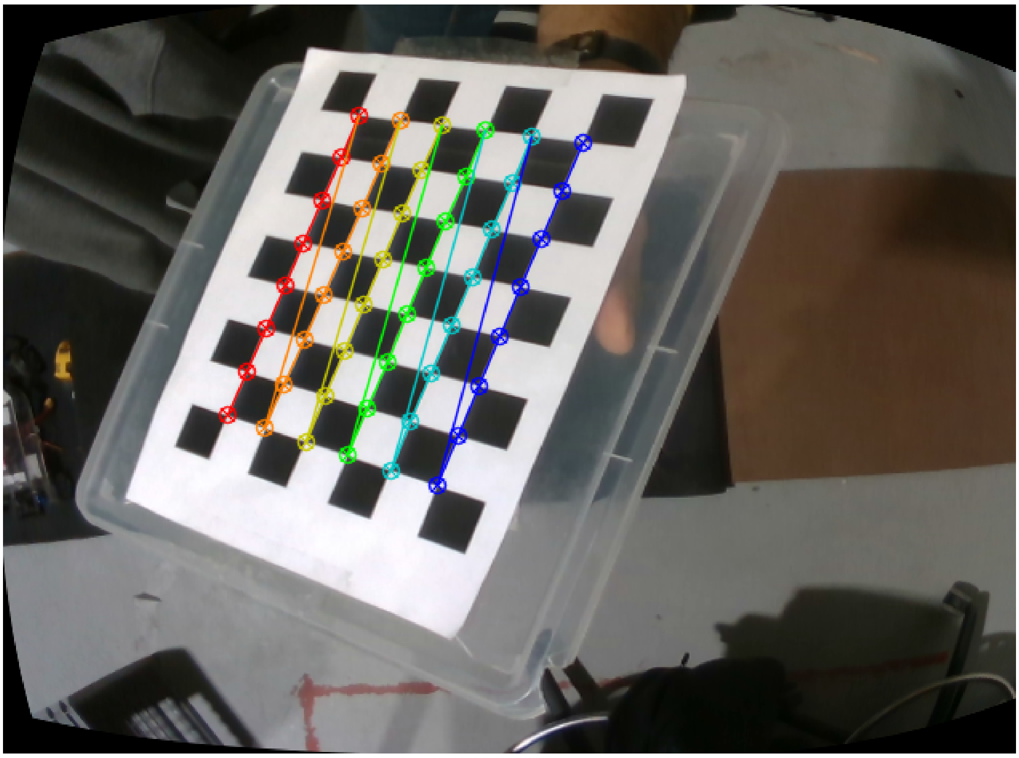

Figure 4: Un-distorted fig - actually more distorted, hinting to pre-processing done in camera

Further, I also worked on the project management end of things. We have been using JIRA and setting up regular spring planning and stand-ups. I was also working with Jash to obtain the pose of the RC car. Lastly, I have started working on the lane detection for the perception.

2 Challenges

2.1 Infrastructure Hardware

One of the infrastructure units that was manufactured had a big problem. the trunk of the unit which was supposed to be vertical was actually at a negative angle. This caused the cantilever which houses the camera to be tilted upwards. This could be huge issue because it not only changes the orientation of the camera but also the height. We tried un-mounting and remounting the cantilever and truss multiple times but could not fix the issue. Finally, I decided to artificially load the truss and pull the cantilever down instead of the truss being naturally loaded by the cantilevers self weight. This required manufacturing additional gussets and mounting the truss at a lower height. Laser distance measurement was used to obtain the accurate depth and match it with the other infrastructure units. Solving this hardware issue took a lot more time and energy than anticipated. It was extremely challenging to have the cantilever on the loaded truss at 2.8m height with a wobbling trunk. However the problem was overcome and we have 3 consistent mounts. We added dead weights to increase the stability of the mount and it is stable to sustain a force of 50kg at a height of 1.5m without starting to topple.

2.2 RGB calibration

Calibrating the Realsense RGB camera is very challenging. There are 3 different channels through which the calibration can be done. They are: the Intel calibration tools, ROS, OpenCV. The calibration tool gave results that were not accurate and which produced outputs with centimetre level accuracy. The ROS method is extremely difficult to write onto. The simpler method is to have another node that publishes the calibration matrix to the ROS main node. ROS uses the camera intrinsic as defined in realsense and obtains extrinsic based on that. The third method is using OpenCV for calibration. This uses chessboard and gives the intrisic, rvec, and tvec. On validating the results it was seen that the values are not accurate. Validation of the camera will thus be a future step.

3 Team Work

This section talks about the work the team members have been doing in the project.

- **Jash Shah**: Jash worked on Aruco marker detection and making the identification of the colored marker on the car more robust. He tested the implementation from different heights and for different lighting conditions. There were various realisations after these tests which he has included in his ILR.

- **Shreyas Jha**: Shreyas mainly worked on multi - device ROS and time synchronization based on ntp. He has also been working on the robustness of the Teleportation and is primarily responsible for the RC car functionality.

- **Ronit Hire**: Ronit worked on the PID control as well as on perception. He set up the entire pipeline for perception and also set up the ROS framework for perception. He was responsible for the ROS architecture. He is also been working on the controls aspects of the car and simulating the latency of the vehicle.

- **Atharv Pulapaka**: Atharv has been primarily involved in implementing MPC. He is working on testing hardware in the loop simulation as well as generating a acceleration profile. He has additionally been working on the PCB part of the project.

4 Plans

The path forward for the team can be divided in various fronts

- **My Plans**: The next step for me is to work on the perception system now that the mechanical manufacturing of the infrastructure is complete. I will start with lane detection and deviation of the car from the center-line. Next I will be working on fusing the depth camera data with the RGB camera data to get the real world transforms to convert image frame to real world frames. Further I will also work start work on the mechanical setup of the car and preparation for the SVD.

- **Team Plans**: The team will be working on various fronts. Firstly, we will try to make the tele-operation on the RC car robust. We will also try to complete the initial perception of the system and do the initially integration of all the sub-systems on ROS. The aim would be to be able to identify the lane and get the center-line. Further, identify the aruco markers to get the reference line and identify the color marker on the car. These would be used to get the pose of the car and the deviation from the centerline. The team will also implement velocity dettection using optical flow methods.