Automated Driving Using External Perception

Individual Lab Report - ILR02

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Team E - Outersense

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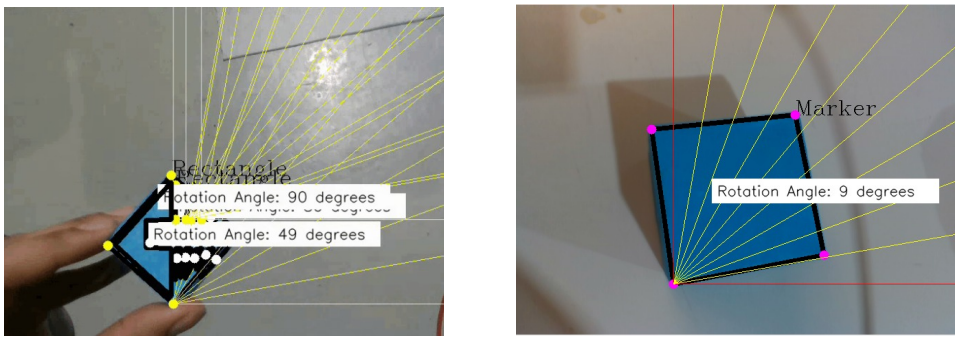
1 Individual Progress

For the MRSD project, I have been working majorly on two major fronts, the perception stack as well as the manufacturing of the track setup.

1.1 Perception

The Intel Realsense cameras will be mounted at a height of between 2.5-3 meters. From this height, it is critical that our perception stack work accurately with a reasonable frame rate. To do so, it is important that the identification and tracking of the marker are invariant to lighting conditions as well as the perspective it is being viewed from. Since the last progress review, I have worked on improving the robustness of the detection algorithm to account for variations in illumination as well as warp. As visible in Figure 1, the algorithm is able to detect the identifier with fewer artifacts. I achieved this by identifying better threshold values for the HSV filtering. Moreover, I was also able to achieve better performance in cluttered environments by varying parameters of the shape detection algorithm as well as the area filter.



(a) Before **(b) After**

Figure 1: Angle detection algorithm performance with change in perspective and lighting conditions

1.2 Track setup

Ensuring optimal track setup is a top priority for our project, as it is critical to thoroughly test the perception stack and control system's latency budgets in real-world conditions. While simulations provide useful estimates, testing on the actual track will yield invaluable data for our project. To avoid any potential delays to our timelines, Ronit and I stepped in to assist Dhanesh with his manufacturing responsibilities, as we had to expedite the process. In particular, I focused on drilling precise holes in the aluminum square sections and riveting the stands to the central section. As can be seen in Figure 2, the infrastructure mount which is being manufactured needs two people; one to hold the stand in place and the second to drill the holes accurately at those locations. Currently, one stand has been manufactured and is being tested with a cantilever beam for vibrations and other disturbances. Further, throughout this time, we also manufactured the 3-layer track (Pink foam, wood and rubber carpet) and set up a sample track outside the NavLab.

Figure 2: Manufacturing of one of the infrastructure mounts

2 Challenges

2.1 Perception

In the perception subsystem, a major hurdle that we faced was to make the identifier detection algorithm invariant to warp. Currently, I have made the solution work to a certain extent but in order to make sure that it scales to a camera that is mounted at a height of 3 meters, the algorithm needs to be further fine-tuned. To do this, I can further tune the HSV color filter. Achieving absolute warp invariance will help us scale this algorithm to real cars or RC cars which do not have an identifier on them.

2.2 Manufacturing

As for the manufacturing of the infrastructure units, one of the major issues we are facing currently is the vibrations that occur because of the height of the structure. Once the cantilever arm and Intel Realsense are mounted to the current structure, the problem will exacerbate. We could mitigate this risk by introducing weights in the form of sandbags or other weights to ensure there is minimal vibration at the base of the units. Furthermore, prototyping and manufacturing robust Intel Realsense mounts is another challenge we are actively trying to overcome. We need to make sure there are no vibrations on the cantilever because it can cause the camera to shake. Consequently, there may be inaccuracies in detecting the identifier and fixed markers.

3 Teamwork

As for teamwork, each of us are flexible and even though we have our own verticals, our team structure allows us to collaborate with each other to complete high-priority tasks faster.

- **Ronit Hire**: Ronit has been involved in guiding and aiding all the subsystems as and when required. He helped with the manufacturing of the infrastructure sensors, improve the perception algorithm, and also work on the control simulations with Atharv. Personally, Ronit and I collaborated to improve the performance of the perception algorithm. He has also been looking after the management and logistics of the project.
- **Shreyas Jha**: Shreyas is currently involved in establishing an onboard control and computing system for the RC car, utilizing a microcontroller. In order to achieve this, he eliminated the original radio communication system that was present on the car and was successfully able to control the steering and throttle of the vehicle.
- **Dhanesh Pamnani**: Dhanesh has taken charge of the track surface design and infrastructure sensor mount manufacturing because it is a key factor contributing to our project's success. Ronit and I are helping him expedite this process so that this concentrated effort can enable us to transition seamlessly to on-track testing.
- **Atharv Pulapaka**: Atharv has meticulously examined the Simulink-based examples of lane-keeping systems that use MPC (Model Predictive Control) to comprehend how this controller behaves in various scenarios. This study will help us make informed decisions about the control architecture to be used.

4 Future work

4.1 Personal

On the personal front, I will continue contributing to both, the perception as well as the manufacturing subsystems. There is still a significant portion left as far as manufacturing goes and hence, it would require most of our attention during this time. The perception stack requires some optimization and must be completed parallelly along with the aforementioned manufacturing goals.

1. Make the identifier angle detection algorithm more robust to warp and perspective changes
2. Begin on-table and on-track calibration of the infrastructure sensors
3. Aid Dhanesh and Ronit in completing the manufacturing of the infrastructure mounts

4.2 Team

As for the future work of the team, we wish to achieve the following goals.

1. Begin designing and prototyping Intel Realsense camera mounts
2. Control the RC car via ROS messages and send back sensor data over WLAN
3. Decide a control architecture and start implementing it