Automated Driving Using External Perception

Team: Ronit Hire, Dhanesh Pamnani, Shreyas Jha, Jash Shah, Atharv Pulapaka

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Liam Pederson, Najam Baig, & Viju James

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1. Individual Progress

We have reached the stage where we are moving towards more integrated testing and improving on system and less on design / architecture development. This report focuses more on integrated testing.

1.1 Handling intersection

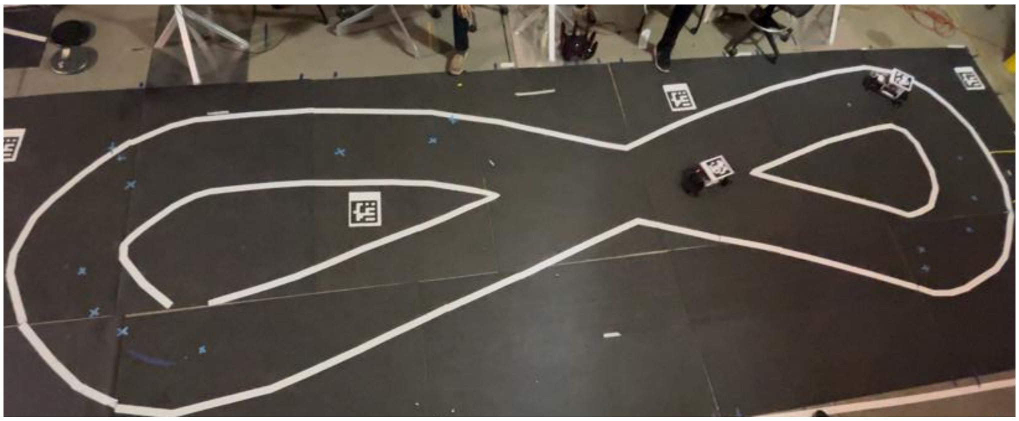

Figure 1 : Integrated test with 2 cars

This problem involved creating a decision-making system for remotely controlled (RC) cars at intersections. In the initial version, we designed a logic framework based on environmental data, defining specific intersection regions. In these zones, RC car speeds were adjusted to avoid collisions. Testing and parameter tuning enhanced the system's reliability. However, the initial version required detailed information about the heading and positions of all vehicles which failed in some regions and certain times. Additionally, there were still edge cases where this logic failed.

To address this limitation, we developed an improved version. This version successfully managed scenarios that previously led to failures. It significantly reduced data requirements, relying only on the controlled vehicle's position and an intersection safety variable. Extensive testing confirmed that this updated system doesn't encounter failures. Nevertheless, more testing is needed to ensure its reliability under various conditions, making it suitable for real-world use in managing RC car intersections. The system was kept running for more than 15 minutes to monitor behavior and identity failure cases. Figure 1.1 shows track with intersection on which system is tested.

1.2 Drive rc cars in a loop to improve estimation

In the subsequent testing phase, the system was subjected to continuous operation with two controlled vehicles following a fixed trajectory. Our primary focus was on enhancing the accuracy of the state estimation component. This involved continuous monitoring of perception data and the fusion of sensor data from the state estimation system. We then fine-tuned the state estimation process which involved tuning the covariance matrices and other parameters to provide reliable state estimates, particularly in scenarios with lost or noisy perception data. This improved state estimation was pivotal for generating less noisy heading estimates for the Model Predictive Controller (MPC), which, in turn, determined acceleration and steering commands for the vehicles. System failures were closely monitored, and root causes were addressed, leading to refinements in the system's performance and robustness.

1.3 Testing with planner

During the integration process with the planner system, we connected it to the control system. The planner generated a trajectory for a defined lookahead distance, which the Model Predictive Controller (MPC) used as the desired trajectory. Initially, the planner used the road's centerline as the desired path to keep the controlled vehicle within its lane and follow the planned route. We started testing with one vehicle and then expanded to two. The system went through numerous runs, identifying scenarios where either the planner or the control system failed. We made iterative software adjustments and fine-tuned parameters to address these issues. While we developed and tested a new planner version, it still faces challenges when dealing with static obstacles. Although the vehicle stops successfully in such cases, finding an alternative path around the obstacle occasionally fails. We are actively working on enhancements and further testing to resolve this specific problem.

2. Challenges

2.1 MRSD project

- Challenges were mainly in the intersection region and finding the best logic that handles all edge cases and is robust.
- Additional challenges arose when adapting the control system (MPC) code to interpret the planner's trajectory. The MPC was designed with specific expectations about the format and structure of incoming trajectory data from the planner. To meet these requirements, we made essential modifications to the planner's output format, ensuring seamless integration with the MPC. Importantly, these changes did not compromise the integrity of the planner's output data; we preserved the planner's commands while ensuring compatibility with the MPC's requirements
- On testing multiple runs cases were identified where tuning cruise control was required to ensure cruise control doesn't fail and stops vehicle to maintain safe distance with other vehicles

3. Team work

Ronit Hire: Ronit worked on ensuring perception units are able to detect and track multiple cars. He generated unique IDs for each vehicle that helped the control system to associate data with respective cars. He is working on eliminating dependence on aruco markers for vehicle detection. He is currently working on ensuring the perception system is more robust. We both conduct integrated testing and check for failure cases.

Shreyas Jha: He has worked on fusing camera data with odometry and IMU to get more accurate state estimates. He also worked in resolving the low level RC control issues to ensure the car followed the command given by MPC. We worked on fine tuning RC cars to follow speed and steering commands correctly. We also conducted integrated tests to ensure system robustness.

Dhanesh Pamnani: Dhanesh and Jash developed the planner system that gives collision free paths for controllers to follow. We tested the planner with other systems and identified places where planner logic needed to be changed.

He is currently working on solving existing problems regarding the planner and then will test again with other systems.

Jash Shah: Jash is working on the planning subsystem, he and Dhanesh both are involved in planner development. We all are conducting integrated testing and ensuring planners behave desirably. He is currently working on the planner to handle static obstacles and generate alternate paths to avoid collision.

4. Future Plan

- The next step is to add dynamic obstacles and check system performance.
- Continue with existing testing with all systems and only controlled cars to improve performance