OuterSense

Automated Driving Using External Perception

Individual Lab Report - ILR09
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Team E - Outersense

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1 Individual Progress

For this PR I worked on covering up all the pending tasks from the previous PRs and also worked on the planning subsystem. The tasks that I focused on this PR was to make the planner system, and build the first iteration of the planning system. The sections below talk about these, the challenges faced and other things I worked on during the last PR.

1.1 Planning system design

As detailed in the previous ILR the system architecture is something taht we really put in time and effort to trace out. The figure 1 here shows the system diagram

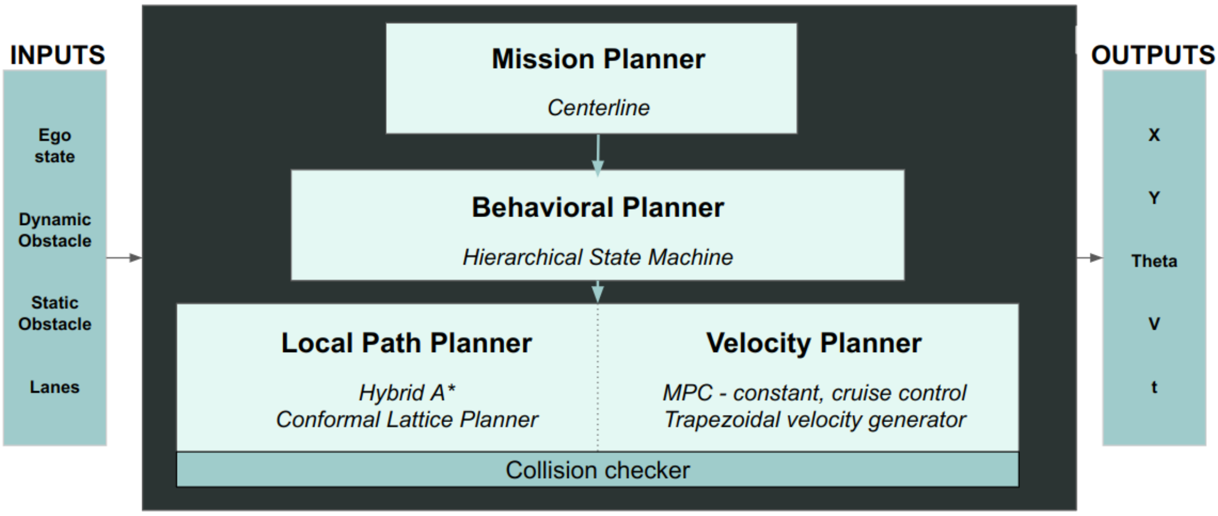

Figure 1: Planning architecture

The Mission planner is just the waypoints and is used to give the goal pose to the local planenr. This forms the top of the hierarchical planner. It takes the current position of the robot and gives the goal position. For our use case however it will just give a constant output that would be the center-line of the figure 8 track. The next behavioral planner is described in the next section.

1.2 Behavioral planner

The second stage is the Behavioural Planner. It takes input as the Mission plan, the information of the road and the information of other agents on the road. For our use-case since we have an intersection the planner would be a hierarchical state machine where the state machine at the intersection would comprise of 4 states, Track velocity, Follow Leader, Decelerate to a stop, Stay stopped. The Behavioural planner state machine for intersection is described in detail in Figure 2. It treats the intersection as a stop sign and the rest of the region as free region where it just switches between 2 states, the track velocity state and the follow leader state. We have a few conditions that have been mentioned in the diagram that help in knowing when to switch between the states. We were having a small problem with this however that we are currently fixing.

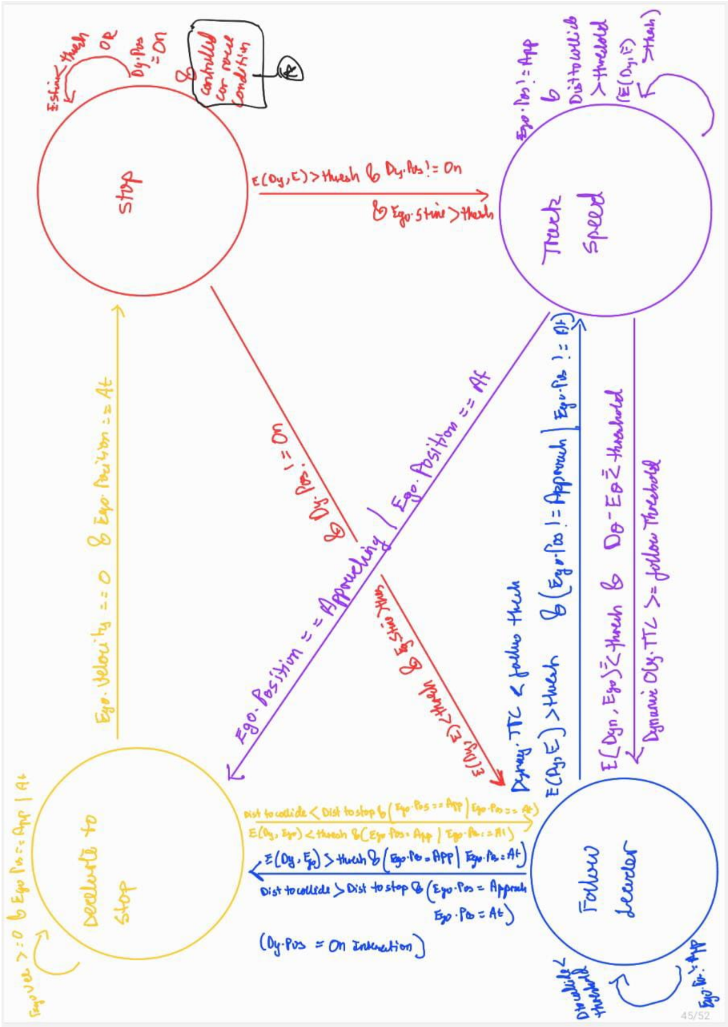

Figure 2: The Behavioural planner

1.3 Hybrid A* local planner

The last part of the planner is the local planner. It is further divided into a path planner and a velocity generator. The velocity generator is being handled by the MPC , the path planner is a Hybrid A* planner which adheres to the Kienodynamic constraints of the car. It calculates a reeds path with and calculates the cost to reach the goal and produces the least cost path. The pixels in the image of the map are the cells. It then does a collision check to check whether any of this intersects with static of dynamic obstacle or leads to the car to go outside the lane. The figure 3 shows the algorithm for the planner. Next it selects a path that is free of obstacles and closest to the center-line of the track. The figure 4 below shows the plan for 1 car. The figure 5 shows the plan for 2 cars, there is a bit of a lag when 2 cars are being planned together. The figure 6 shows that no plan was generated for the obstacle and hence the car was asked to stop and figure 7 shows the plan around the obstacle. The planner solves a cubic spline with the constraints to get the path and interpolates to re-enter the lane if it goes out.

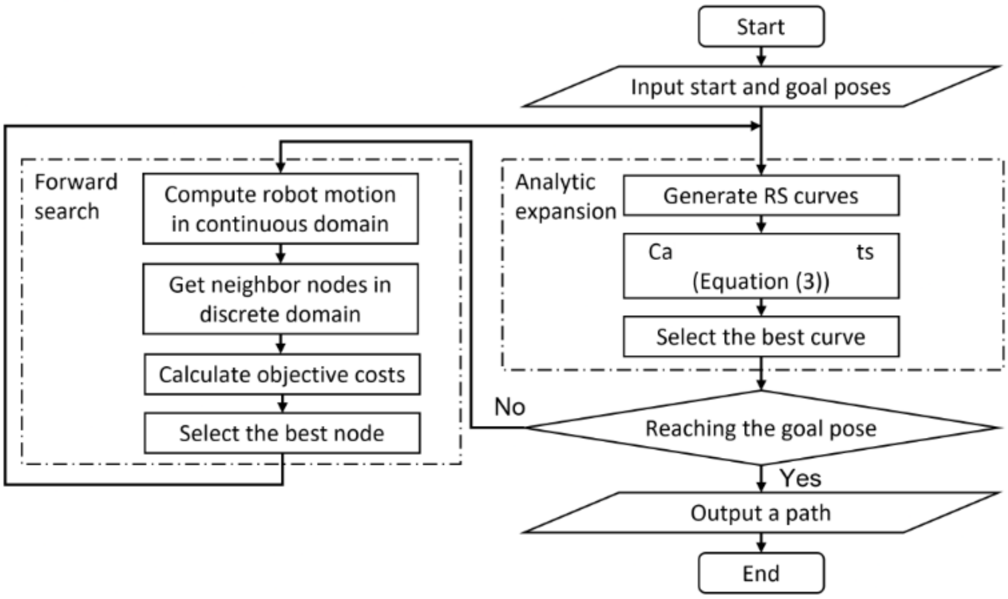

Figure 3: Planning Algorithm

Figure 4: Planning for one car

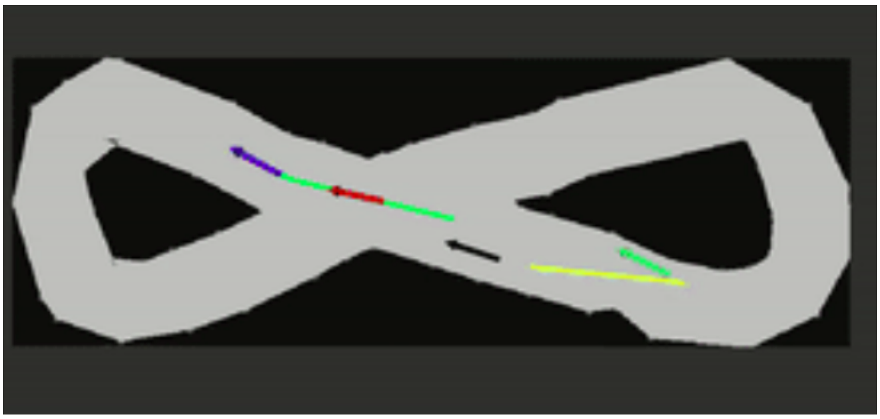

Figure 5: Planning for 2 cars

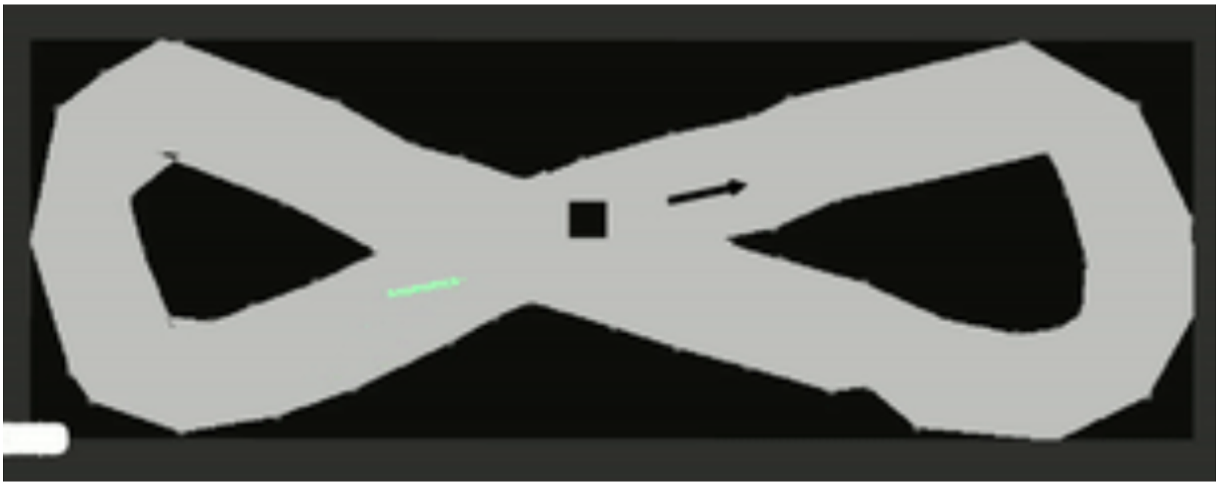

Figure 6: stops if obstacle in between

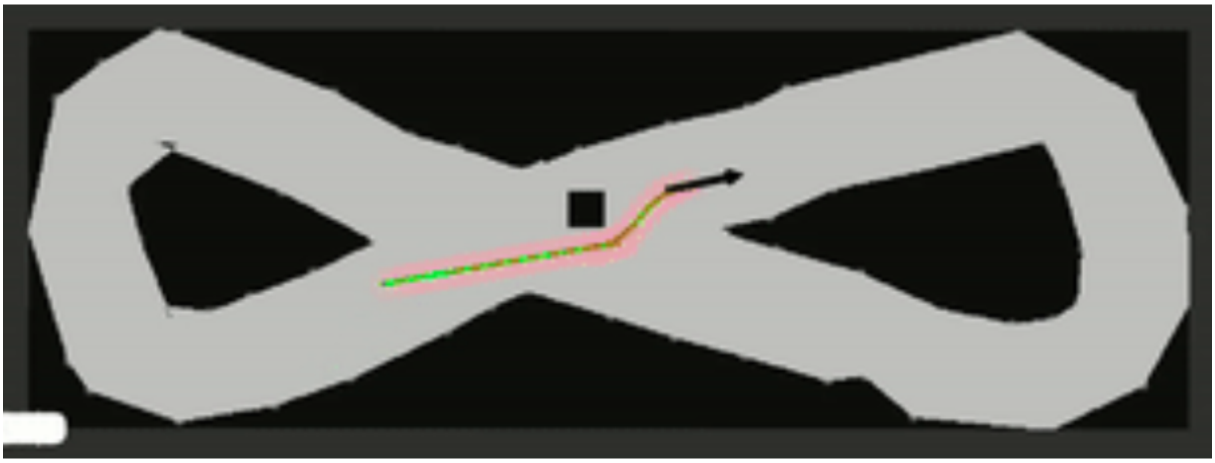

Figure 7: Planning around obstacle

We know that this is a complicated approach to the problem and hence are choosing to follow different approaches parallel with this. The most basic approach is to have cruise control as a part of the controller and the planner just works as a simple state machine. For dynamic obstacles the controller goes in cruise control mode and for intersection the planner dictates the state. For static obstacles the car just stops behind it.
The second intermediate version would be to have a hybrid A* for static obstacle avoidance which can be integrated with this basic version defined. While these basic versions are working we will be working on the planner described above and try and integrate it in the system.

2 Challenges

2.1 Not able to plan around obstacles

This is a surprising challenge that we have right now. The planner is really fast it runs at 3ms and is extremely roboust. However, given that the lanes that we run our car in are rally tight and we cannot really go reverse (sponsor requirement) we are facing a challenge that when there is a static obstacle in the lane the planner either stops giving a path or it gives a path around the obstacle after solving for all possible ways of going around the obstacle given the kineodynamic constraints of the car and the geometry of the track. This takes some time, I have a hunch it is also because the goal is right next to the obstacle and taking a reverse is discouraged. Tuning the parameters reducing the map size changing the heuristics and following the other suggestions given would help us mitigate this issue.

2.2 Detection fails in certain region

During the testing of the system, we continued with the same process that we always did. However, we were trying to run the Rc cars in a figure of 8 like how it would run during the FVD. What we observed was that the pose obtained after fusing the perception and odometry was jumping at the far end under camera 3. We first suspected that the VESC was misbehaving but on further detailed analysis we found out that the real issue was that the perception tracking of the car was failing. We looked into the perception system but could not find any problems that would cause this issue. Finally, we understood that the really problem was that the camera was not working on times and there was frame rate drop. this is surprising because as risk we had anticipated the camera not working and hence we had 5 cameras - one borrowed from the Pepper Gripper team, when we needed 3. Both of these were however not working and the one that is on the infrastructure has started signs of wear. We have to recalibrate this camera and get a new one at the earliest if we want to keep no stones unturned for the FVD.

3 Team Work

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

- **Jash Shah**: Jash and I were together on the planning system. He helped me in understanding how to implement the planner on ROS. He owned the task of making all the nodes and how they interact with the other systems. He also worked on the planner with me.

- **Shreyas Jha**: Shreyas integrated the VESC IMU package into the RC car's software. He is further fused odometry from the car and IMU reading with the perception to get a reliable pose of the object even when the car is stationary. It also made the pose estimation really smooth. This also helped to solve the problem of yaw value of the vehicle when it is at rest.

- **Ronit Hire**: Ronit worked on the perception system. He has been working on multi car detection and tracking. The tracking of the vehicle is a huge challenge as the tracker gives an ID to each object and if the tracker is reinitialised the ID changes. Data association is another challenge in this that Ronit is working on. The way he is tackling this is by using the Min-Cost Flow muSSP

- **Atharv Pulapaka**: Atharv has been working on the control of multiple RC car. He has also been working on making the MPC more robust. He tested the cruise control for 2 RC cars. Further he modified teh existing follower to follow the path provided by the planner

4 Plans

The task of eliminating Aruco based detection and tracking and performing data association is still on going. Ronit is owing this piece. Shreyas system is more or less freezed at this point with minor tuning needed. Atharv is working on implementing cruise control for 2 controlled and 1 rogue vehicle. He is also working on writing an intesection handling check. I am writing the planner as described above and Jash is helping me with it.

- **My Plans**: As a priority I will be working on making the planner work with obstacles and give the center line of the track as the path to the plan as a general rule of thumb. We received really great feedback from the TAs and Professor Dolan during the meeting and previous PRs and we will be implementing those to speed up our planner. I will be leading this system and Jash will be helping me in every step. the aim is to get the planner up and running and test it robustly before the FVD with the otehr systems together.