Path Planning Project

1. Introduction

The objective of this project is to design a path planner that is able to create smooth, safe paths for the car to follow along a 3 lane highway with traffic. The path planner is be able to keep the car inside its lane, avoid hitting other cars, and pass slower moving traffic all by using localization, sensor fusion, and map data.

2. Implementation

In order to achieve the main objective, we have defined two main tasks that have to be solved. First, we have to keep the car inside its lane a create smooth paths along the road (in order to avoid high acceleration and jerk values). Second, we have to monitor the traffic around the car so when slower moving car is detected ahead the current speed should be reduced in order to avoid collisions. In addition, a safe take over procedure should be performed in case the neighbouring lane is free. The two tasks are treated in more detail in the next subsections.

2.1. Lane Following

The goal is to create smooth paths along a lane following the shape of the road. The shape is available from the map data and it is defined by waypoints. Since waypoints are discrete and car motion is continuous we have to model a smooth and continuous signal (trajectory) that passes through the waypoints ahead. We achieve that by using splines that pass through waypoints at 30, 60 and 90 meters ahead. In addition, and in order to achieve motion smoothness, the splines also match the points from the previous iteration (or time interval). The consequence is that for each iteration the new trajectory is an update of the previous one rather that a complete substitution.

2.2. Avoiding Collisions and Path Optimisation

The first task is to reduce the speed in case a slower car is detected (close) ahead. By constantly analysing the sensor fusion data, we detect cars that are less than 30 meters ahead and that move with a speed lower than the current speed of our car. If such car is detected, the speed is smoothly reduced until it matches the target speed. We define the target speed as the 90% of the speed of the (slower) car moving ahead. By doing so, we avoid unnecessarily drastic speed reduction but we keep a margin to increment the gap between the vehicles in case, and in spite of braking, we get too close (i.e. less than 30 meters) to the car ahead.

The second task is to safely pass slower moving cars. In order to do so, we check whether any of the neighbouring lanes is free. We define a lane as being free if:

- There is no car at least 30 meters ahead.
- There is no car 10 meters around (ahead or behind).
- The car behind is at least 15 meters behind and it will be so after the lane change is completed.

All these checks are performed in the `is_lane_free()` function.

3. Results

An example of the resulting driving performance can be found in the `videos` folder. The car drives safely and smoothly around the track, without excessive acceleration and jerk, and aims at minimising the driving time by passing slower vehicles. And example of a safe take over is shown in Fig. 1.

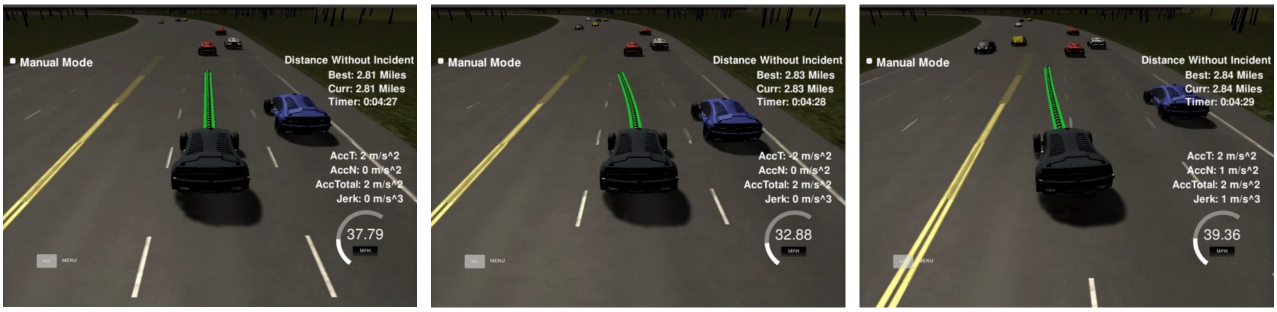

Figure 1: Example of passing a slower car.

4. Discussion

The car is able to safely drive around the track and pass slower moving cars. However, we have detected the several issues that can potentially yield improvements in the car behaviour, e.g.,

- The car is only "seeing" one step ahead. In other words, if a lane is free to pass a slower moving car the car will perform the take over. However, the target lane can be obstructed further ahead by even slower moving cars.
- As a consequence of this "one step ahead policy" the car can get trapped in a slowly moving traffic if the only adjacent lane is not free (so we are currently moving in the right or left lane) but the next one is. In such cases, it would be worth considering slowing a little bit more in order to "free" the adjacent lane and move to the fast lane.
- In highway traffic, at least in Europe, the car is to always use the right-most lane unless it is passing a slower moving cars (there are however exceptions e.g. congestions, highways in urban areas, etc.). Therefore, it would be interesting to adjust the policy so the car always returns to the left lane (if possible) after performing a take over.