Model Documentation

The Path Planning Project in Term - 3 of Self – Driving Car Nano Degree course involves driving around a simulated highway, with traffic present on a three lane road. The goal is to successfully navigate through the track without crossing the speed limit of 50 mph, without driving out of line, avoiding collisions and making lane changes when possible.

Before going deeper into how the issue was resolved, let us discuss a few relevant topics.

Coordinate System

We are all familiar with the Cartesian coordinate system of (x, y). While many calculations and trajectories predicted in this course were done through the same, we also used a second coordinate system, the Frenet coordinate system. It became useful especially in case of applying constraints on the vehicle for adhering to safety and feasibility.

- Frenet Coordinate System: Here the longitudinal displacement, along the vehicle's heading forms the s – coordinate. The lateral displacement from the center of the lane gives us the d – coordinate and describes where the car is positioned along the width of a lane

Feasibility vs Comfort vs Safety

Before making any change, it is necessary to check if it is feasible, say making a lane change when no tarmac is present on that end and so on. It is therefore important to first check if the change is possible at all. Once we confirm it is possible, we then need to decide if the change follows safety norms. We can't drive on the wrong side of the road, just because a lane change is technically possible. So after feasibility checks, we check if a change is safe for the vehicle and follows legal norms. Lastly when all else is satisfied, we check if the change is comfortable for the passengers in the vehicle. Just because lane changes are possible, constantly changing lanes or having a jerky change, may not necessarily be pleasing to the passenger, which makes us change our situation only if smooth and pleasant.

Taking all these into account, we apply constraints on the driving of the vehicle through the highway

Spline.h

Spline.h is a utility provided with the classroom material, that is similar to a polynomial fitting function. Using the same, we can take a series of points and fit a polynomial through them. Once the polynomial is realized, we can even use an object of the same to calculate x or y values, given y or x, in the Cartesian coordinate system.

Model

Let us now discuss the model that was used to plan path for the vehicle through the highway course

To plan the path, the following steps were performed

- Sensing the environment: Through sensors present in the car, objects moving around the car were detected, including their velocities and positions in both Cartesian and Frenet coordinate systems
- The previous path travelled was also obtained to maintain a continuity in motion
- Using the end points of the previous path, three points spaced 30m were calculated using the car's position and heading. These three points were then used to form a trajectory polynomial using spline
- Once the polynomial was drawn, waypoints are created across the line using the current speed of the car as a factor. It is along these waypoints that the car moves. The spacing of this points directly affected how fast the car shall move because the time to move between consecutive waypoints is always the same
- Using the sensor data, we can perform certain checks for collisions and lane changes using Frenet coordinates
    - For collisions, we check if any car is present ahead of our vehicle by a certain distance in the s dimension. If present, we decrease our velocity progressively
    - We also check the neighboring lanes to see if traffic is present around us and how far they are from the car. We change between lanes using the d dimension
    - If a vehicle is present in our present lane and some other adjacent lane has lesser traffic ahead and behind us, we make a lane change by changing the d value in the waypoints for planning the trajectory (lines 263 – 335 : main.cpp)
    - We also keep a reference velocity, which is incremented and decremented on small steps depending on a change in obstructions, so that there is no jerk in movement of the vehicle
- Thus, we sensed our environment and planned our behavior accordingly, which was then passed on to a trajectory planner that converted it into a path that could be followed safely