Path Planning Project

The goals / steps of this project are the following:

- Building a path planner that creates safe trajectories for the car to follow.
- The car should obey the speed limit of 50 MPH, avoid colliding with other cars, be able to change lanes safely when necessary.
- Every 20 ms the car will move to the next waypoint on the path.
- The car should drive 4.32 miles around the track without any incident.

Model Logic Summary:

Our goal is to generate a smooth path for the car to follow. In order to do so, we must address a few points:

1. Make a smooth transition between waypoints.
2. Keeping the car in its lane.
3. Avoid colliding with other cars.
4. Obeying the speed limit.
5. Changing lanes safely when necessary.

Points 2 to 5 are discussed in the following section. As for point 1, to generate a smooth path, as explained in the walk-through video, we use points from the previous path in our next one.

Each path consists of 50 waypoints, so whatever points left from the previous path are used in the next one, and the rest is generated (to complete 50 waypoints for the new path).

These new waypoints are generated using the spline library. First the spline object is created and is initialized by 5 points, 2 from the previous path, and 3 new ones which are relatively far from each other. The reason behind this is for the spline object to use these points to interpolate the actual waypoints that will be used in the final path and will ensure that the path is smooth.

Rubric Points:

- **The car is able to drive at least 4.32 miles without incident..**

  The planner was tested multiple times and the car was able to drive around the track safely and efficiently at least 4.32 miles.

  The logic used for most of the project is similar to the one explained in the walk-through video in the lectures.

- **The car drives according to the speed limit.**

  The car starts with speed = 0 and starts accelerating with a constant acceleration (After trying different values I settled on 7 m/s^2) until it's just below the speed limit. As long as there are no other cars in front of us in the same lane, the speed will remain constant at approximately 49 MPH.

- **Max Acceleration and Jerk are not Exceeded.**

  The amount by which the speed is incremented or decremented is calculated so that the acceleration is around 7 m/s^2. This is calculated by multiplying the target acceleration by the time elapsed between each two waypoints (20 ms) to get the speed in m/s, and finally multiplying the result by 2.24 to convert it to MPH.

- **Car does not have collisions.**

  Collision avoidance is handled using the sensor fusion data by first checking the lane in which each surrounding car is. If there is a car in front of us in the same lane within a certain range, we start decreasing the speed and checking for adjacent lanes for a possible lane change.

- **The car stays in its lane, except for the time between changing lanes.**

  Staying in the same lane is quite easy using the Frenet coordinates and knowing the width of the lanes (4 m). We just keep the *d* coordinate of the car constant depending on which lane we are in. So for example if we are in the middle lane, we set $d = 6$ (4 m for the left lane + 2 m to drive in the middle of our lane).

- **The car is able to change lanes**

  Changing lanes is only considered if there's a car in front of us in the same lane and driving slowly. We first check the lane on the left, if there is a car then we check if it's too close to our car (i.e. not enough gap to make a lane change). If the neighbor car is more than 25 m ahead of us or more than 20 m behind us, it's safe to make a lane change. The same logic is repeated for the lane on the right.