Rubric Points Discussion

- **The Model:** *Student describes their model in detail. This includes the state, actuators and update equations.*

The model implemented in this project is the Kinematic model which takes into account within its equations the vehicle's x_t and y_t coordinates, orientation angle ψ_t, and velocity v_t. In addition to that to make the model more complete are included the cross-track error cte_t and psi error $e\psi_t$. Moreover, the actuators outputs are the acceleration a_t and the steering angle δ_t. All the terms cited are function of the time, therefore the model combines the state and the actuations from the previous time step to calculate the state for current time step based on the following equations:

$$x_{t+1} = x_t + v_t * cos(\psi_t) * dt$$

$$y_{t+1} = y_t + v_t * sin(\psi_t) * dt$$

$$\psi_{t+1} = \psi_t + \frac{v_t}{L_f} * \delta_t * dt$$

$$v_{t+1} = v_t + a_t * dt$$

$$cte_{t+1} = f(x_t) - y_t + (v_t * sin(e\psi_t) * dt)$$

$$e\psi_{t+1} = \psi_t - \psi des_t + (\frac{v_t}{L_f} * \delta_t * dt)$$

where d_t represents the time elapsed within two steps.

- **Timestep Lenght and Elapsed Duration (N & dt)**: *Student discusses the reasoning behind the chosen N (timestep length) and dt (elapsed duration between timesteps) values. Additionally, the student details the previous values tried*

After several attempts, the value respectively chosen for **N** and d_t are **19** and **0.095**. These values mean that the optimizer is considering a **1,805** seconds for the event horizon. Shrinking this period of time made the car off the track introducing a component of instability or alternatively it turned to be fall far short to make any predictions on the trajectory, ending up with a sudden stop of the vehicle along the curves.

Full disclosure, other values for **N** and d_t tried were 10/0.1, 15/0.1, 25/0.095, 35/0.05 and many others, all of them introduced an erratic behaviour in the control system.

- **Polynomial Fitting and MPC Preprocessing:** *A polynomial is fitted to waypoints. If the student preprocesses waypoints, the vehicle state, and/or actuators prior to the MPC procedure it is described*

First of all, the waypoints were transformed from map's perspective to car's perspective. Doing so the process to fit a polynomial to the waypoints are much simplified since the vehicle's x and y coordinates are translated to the origin and the orientation angle is also null.

- **Model Predictive Control with Latency**: *The student implements Model Predictive Control that handles a 100 millisecond latency. Student provides details on how they deal with latency.*

Within the simulation was included a latency which represents the reaction of the system to the actuation. Therefore, this means the effect of the outcomes of the cinematic equations can be executed another step later than the ideal conditions. To deal with this aspect I tuned the cost function with different weights in order to approach, especially along the curves, the vehicle in a smoother manner strongly penalizing the combination of velocity and delta.