CarND MPC

This project implements a Model Predictive Control (MPC) to drive a car over predefined route. The route is given as a sequence waypoints in the car's local reference frame, defined as a 2D cartesian coordinate system with x axis pointing forward from the car's center and Y axis pointing to the left.

The states of the model are:

1. x and y coordinates of the vehicle
2. orientation angle of the vehicle
3. Velocity of the vehicle
4. cross track error
5. orientation angle error

The actuators are:

1. The steering angle value between -25 degree and 25 degree.
2. The throttle value between -1 and 1

The update equations are defined by the following equations

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

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

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

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

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

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

Strategy to choose N and dt:

N is the number of time steps is set to 10 whereas dt is the duration of time step and it is set to 0.1 .N and dt are relatively small to simplify the optimization problems. Initially, I fixed N to be 10 and varied dt. I tried different values of dt (0.05, 0.1).

At the end, I chose:

- N=10
- dt=0.1
- T=1.

To simplify the mpc optimizations and the waypoint polyfits, waypoints have been transformed to vehicle coordinate system.
Position of the car is (x, y, orientation angle) at (0, 0, 0).

To simulate a delay of 100ms in the future,I used the kinematic model . Instead of feeding the waypoints directly prior to the MPC procedure, I estimated the waypoints position at t + 100ms with the following parameters

- x(t+1), y(t+1), phi(t+1) is the estimated waypoints position at t+100ms
- x(t), y(t), phi(t) is the waypoints at time t
- v(t) is the speed at time t
- delta(t) is the steering angle at time t
- dt is 100ms

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

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

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