Project 5 Model Predictive Control Project Writeup

Udacity Self-Driving Car Nanodegree Program, Term 2
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The Model

Student describes their model in detail. This includes the state, actuators and update equations.
I did not find a need to change the model from what was presented in lecture and demonstrated in the "Mind the Line" homework problem. The state variables are position x and y in a plane, heading angle (direction of velocity vector), velocity magnitude, cross track error, and heading angle error. The actuator inputs are steering angle and forward acceleration (negative sign used for braking). The update equations for the state are as follows:

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

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

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

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

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

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

Timestep Length and Elapsed Duration

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.
First I chose N by picking the largest value possible that did not slow down the computation too much. I started with 5 and increased slowly until I found performance decreased. I found that less than 7 and more than 15 did not work at all and that 10 worked nicely.

Second I chose dt by looking at how far ahead of the vehicle that the predicted trajectory was propagating on the track. I wanted a dt large enough that with N=10 the model was planning far enough ahead to prepare for upcoming turns but not so large that the model suffered large integration errors.

Latency

Student provides details on how they deal with latency.
To deal with latency the primary knob was to increase the coefficient on the cost function penalizing gaps between sequential actuator values on the steering angle. Cranking this coefficient up was enough to handle the 100 msec latency.

With this method alone, however, the car had to slow down a lot on the biggest turns. I was able to increase the speed the car completed the track by adding a propagation of the state before passing it into the model predictive control solver. I found that if I propagated the state forward by 50 milliseconds that the MPC would perform better, particularly by initiating the turns earlier. With this addition, the car completed the track even faster.