PID Controller Reflection

1. The effect of the P, I, D components in the implementation.

   To control steering, throttle and breaks for the car, I used PID controller technique in the implementation.

   Proportion Controller (P) is in proportion to cross track error (cte) with respect to reference trajectory. More the error (cte), more car will be turned towards the reference trajectory. But only with P-controller, the car overshoots the reference trajectory and then recovers back. So it would be in a marginally stable condition.

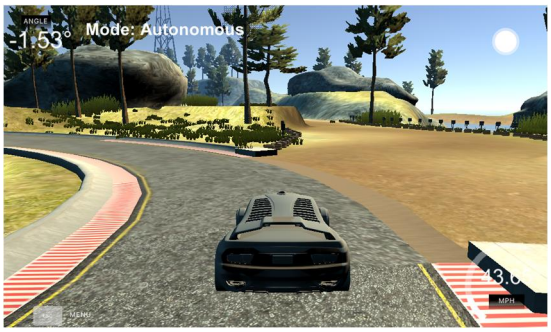
   To make it better, Differential controller (D) is added. With PD controller, the car reaches reference trajectory gently and stays at the trajectory.

   The term "I" is then introduced to compensate for systematic biases. This is the Integral Controller for the steering angel equation which sum all the cross track error (cte) observed so far. With PID controller, we get the steering angle for the car navigation which is much smoother.

2. How the final hyper parameters were chosen?

   For each P, I and D controller, there are corresponding tau parameters (tau_p, tau_d, tau_i). To get the best control gains, I used Twiddle or Coordinate Ascent Algorithm in combination with manual tuning. With twiddle the PID controller converges faster but it overshoot drastically at first.

   First the hyper parameters were manually tuned by trial and error to make sure that Car remains on the drivable path with lesser swings. Then using these manually tuned parameters as a starting point, I ran twiddle algorithm. The car initially had problem turning at the below shown corners. But with manual tuning and twiddle output values, the car could successfully complete the track. The final parameters selected are: Kp = 0.156, Ki = 0.00038, Kd = 3.4 with the speed of 45 MPH.



   The final Video output is available at below link:

   https://youtu.be/V3S5hCrOe1E