Udacity Self-Driving Car Nanodegree

Term 2, Project 4: PID Control

Mark Helms, May 1, 2018

Goal/Summary

The goal in this project is to autonomously control a vehicle in a simulator using a PID controller and knowledge about the cross-track error (CTE) and speed of the vehicle. CTE is generally the distance of the center of the car from the center of the lane. The vehicle must make a single lap around the track.

Approach

Step 1: PID Controller Programming

To program the PID controller, the following formulas were used:

p_error = CTE
d_error = d(CTE)/dt
i_error = sum(CTE)

To retrieve the total error, the following formula was used:

total_error = Kp * p_error + Kd * d_error + Ki * i_error
where Kp, Kd and Ki are parameters selected at startup.

The steering angle selected is:

-1 * total_error / speed

Step 2: PID Parameter Selection

All three parameters work together, however generally, when the other two parameters are held constant, the following hold:

Kp – determines how quickly the car will attempt to turn back on track
- If this value is too low, the car will not be able to successful turn enough on sharp turns.
- If this value is too high, it results in overly jerky steering.

Kd – determines how much the steering will be dampened as the car attempts to get back in line
- If this value is too high, it will take over as a resonating, primary steering controller
- If this value is too low, it will result in the car swinging back and forth as it attempts to correct itself.

Ki – determines how soon the car will notice that it's drifting.
- If this value is too low, the car may not be able to correct a drift in the steering before it's of the road.
- If this value is too high, the car will constantly believe it's drifting and resonate.

These parameters were chosen using manual tuning / twiddling. To start, Kp alone was chosen. When it was noticed that the car would resonate, Kd was made non-zero and tuned. When it was discovered the car drifted to the right, Ki was added and tuned. The first tuning successfully allowed the car to drive forward, however at the first turn, the car failed to steer adequately, so Kp was increased and the other terms were adjusted to compensate. This process was repeated until the car was successfully able to navigate the entire course at 0.3 throttle (the default).

The final parameters chosen were: Kp = 8.0 Ki = 0.008 Kd = 85.3

Special Note Concerning the Performance

It was noticed that the car tends to jerk at some moments while driving. It is believed this is due to the simulator providing CTE relative to line segments instead of curves. The result is a series of step signal responses from the PID.