
Self-Driving Car Engineer Nanodegree Program
PID Control Project
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I begin the project by watching the recorded Q+A session with teacher David Silver. There is a walk through of how to get the program up and running and those steps are followed.

2 different sets of Kp, Ki and Kd settings are demonstrated. These are both tested with similar results to as shown in the video.

As noted in the Q+A video Ki is not going to need adjustment.

Settings : double init_Kp = -1 ; double init_Ki = 0 ; double init_Kd = 0 ; Comment : as per Q+A video .Big osculations before first corner
Settings: double init_Kp = -0.5 ; double init_Ki = 0 ; double init_Kd = -0.5 ; Comment : as per Q+A video. Similar to first terrible before first corner

After initially testing the settings from the Q+A video how best to proceed was considered. The video suggested using command line arguments to run the same program with different setting each time. I decided not to take this approach as by using a hard-coding approach I could keep track of the settings I had tried within the code and just comment out the old settings and add observations into the comments as I went. Also the reviewer of the code can clearly see what I tried by looking directly at the code.

The settings and comments in this report are reproduced from the comments in main.cpp

Beginning by only adjusting one variable and in broad strokes or big steps, then refining

Batch 1: 4 Levels of KP

Settings: double init_Kp = -0.25 ; double init_Ki = 0 ; double init_Kd = 0 ; Comment: Off road before first corner
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = 0 ; Comments: Almost makes complete first corner
Settings: double init_Kp = 0.10 ; double init_Ki = 0 ; double init_Kd = 0 ; Comments:

Round in circles before first corner
Settings: double init_Kp = 0.25 ; double init_Ki = 0 ; double init_Kd = 0 ; Comments: Similar to previous round in circles immediately
Settings: double init_Kp = 0.50 ; double init_Ki = 0 ; double init_Kd = 0 ; Comments: Kp 0.10 and 0.25 and 0.5 all very similar circles immediately

Continuing with experimentation Batches 2 to 6 all take one level of Kp and try 4 levels of Kd. This is to try and find a good combination of Kp and Kd as adjusting Kp on its own did not prove useful and in fact was worse than the initial tests from the Q+A video where both Kp and Kd were adjusted.

Batch 2: One level Kp each with 4 levels of Kd

Settings: double init_Kp = -0.25 ; double init_Ki = 0 ; double init_Kd = -0.5 ; Comments: Starts OK but major oscillations makes it to end of first corner
Settings: double init_Kp = -0.25 ; double init_Ki = 0 ; double init_Kd = -0.25 ; Comments: worse than previous
Settings: double init_Kp = -0.25 ; double init_Ki = 0 ; double init_Kd = 0.5 ; Comments: Worse again than previous
Settings: double init_Kp = -0.25 ; double init_Ki = 0 ; double init_Kd = 0.25 ; Comments: a little better then previous but doesn't make first corner

Out of Batch 2 first the best.

Batch 3: Varying 4 levels of Ki for one Kp

Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -0.5 ; Comment: **MASSIVE IMPROVEMENT** might pass, touches red and white kerb but does lap
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -0.25 ; Comment: a lot worse than previous bigger oscillation and hits kerb on bridge better than first batch of 4 but much worse than previous
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = 0.5 ; Comment: worse again than previous similar to first one or two that made the first corner
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = 0.25 ; Comment: Similar to previous off track before first corner

Out of batch 3, the first was by far the best

Batch 4: one level Kp to 4 levels of Kd

Settings: double init_Kp = 0.10 ; double init_Ki = 0 ; double init_Kd = -0.5 ; Comment: Terrible almost immediate turned off track not quite as bad as the immediate circles but very bad
Settings: double init_Kp = 0.10 ; double init_Ki = 0 ; double init_Kd = -0.25 ; Comments: quite similar to previous off track in 2 seconds
Settings: double init_Kp = 0.10 ; double init_Ki = 0 ; double init_Kd = 0.5 ; Comment: almost same as previous

Settings: double init_Kp = 0.10 ; double init_Ki = 0 ; double init_Kd = 0.25 ; Comments: almost same as previous

Out of Batch 4, all bad.

Batch 5, one level Kp 4 levels Kd

Settings: double init_Kp = 0.25 ; double init_Ki = 0 ; double init_Kd = -0.5 ; Comments: immediately off track
Settings: double init_Kp = 0.25 ; double init_Ki = 0 ; double init_Kd = -0.25 ; Comments: Immediately off track
Settings: double init_Kp = 0.25 ; double init_Ki = 0 ; double init_Kd = 0.5 ; Comments: same as previous 2
Settings: double init_Kp = 0.25 ; double init_Ki = 0 ; double init_Kd = 0.25 ; Comments: same as previous 3 ....terrible

All Batch 5 bad

Batch 6 one level Kp for 4 levels of Kd

Setting: double init_Kp = 0.50 ; double init_Ki = 0 ; double init_Kd = -0.50 ; Comments: like previous 4 , I am wondering is the complier working results are so similar...
Setting:

double init_Kp = 0.50 ; double init_Ki = 0 ; double init_Kd = -0.25 ; Comments: like previous 5!
Settings: double init_Kp = 0.50 ; double init_Ki = 0 ; double init_Kd = 0.5 ; Comments: like previous 6!
Settings: double init_Kp = 0.50 ; double init_Ki = 0 ; double init_Kd = 0.25 ; Comments: like previous 7!

Batch 6 all bad.

Taking the best result and experimenting with that. Levels beyond Kd = 0.5 had not been tried so that was tested.

Batch 7: Kp levels beyond 0.5

Setting: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -0.75 ; Comments: Slightly better than previous best small touches on red and white kerbs, might be good enough to pass
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -1.0 ; Comments: slightly maybe better than previous slightly smaller touches on red and white kerb
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -1.5 ; Comments: slightly better than last one slightly less touches of red and white but steering seems harsher...better chance of passing but less pleasant to be in.
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -2.0; Comments: Slightly better again almost no touching of red and white kerbs but steering slightly harsher than previous

On the basis of above improvements further increasing variations in Kd were attempted.

Batch 8:

Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -2.5; Comments: as per trend slightly less touching on red and white kerbs but harsher steering
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -3.0; Comments: I think this will pass does not touch red and white but does touch yellow line before red and white. need to check rubric requirements.
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -3.5; Comments: I think this is slightly better than previous
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -4.0; Comments: possibly a little better than previous
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -5.0; Comments: jumping to 5 looking for potential improvement..not sure similar maybe steering more wobbly
Settings: double init_Kp = -0.10 ; double init_Ki = 0 ; double init_Kd = -6.0; Comments: Steering a bit harsher but avoid kerbs
Settings: double init_Kp = -0.15 ; double init_Ki = 0 ; double init_Kd = -6.0; Comments: steering a bit hard BUT might be the best so far
Settings: double init_Kp = -0.05 ; double init_Ki = 0 ; double init_Kd = -6.0;

Comments: Slightly worse on red kerbs
Settings: double init_Kp = -0.15 ; double init_Ki = 0 ; double init_Kd = -5.0; Comments: good contender for best does not touch red kerbs but does yellow lines and not as smooth as first good one but better on kerbs

Best so far:
double init_Kp = -0.15 ; double init_Ki = 0 ; double init_Kd = -4.0;

At this stage the settings seemed adequate but some final improvements were attempted.

Final batch of fine tuning:

Settings: double init_Kp = -0.17 ; double init_Ki = 0 ; double init_Kd = -4.0; Comments: best so far
Settings: double init_Kp = -0.13 ; double init_Ki = 0 ; double init_Kd = -4.0; Comments: maybe harsher steering than last

BEST SETTINGS:
double init_Kp = -0.17 ; double init_Ki = 0 ; double init_Kd = -4.0;

With settings decided throttle experimented with.

Default level is 0.3.

Throttle levels 0.3, 0.35, 0.4 and 0.5 all experimented with.

All levels except 0.3 the car touched the red and white kerbs so reverted to 0.3 as final submission level.

Final Settings as submitted for review :
double init_Kp = -0.17 ; double init_Ki = 0 ; double init_Kd = -4.0; with throttle level 0.3