**Vern Francisco**

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**Reflection**

**Describe the effect of each of the P, I, D compenents**

**P effect** – I first played with this component of the PID controller. The effect of this term was to improve the response of the car to correcting to cross track error to zero. It also caused oscillation and frequency of the oscillation increased with increased P

**I effect** – The effect of this term was very strong. Small increases cause very drastic turning behavior. This term is meant to correct steady state error. I'm not sure how much drift, if any is present in the model, but this term works to cancel the drift effect

**D effect** – The effect of this term is to cancel out, or damp the oscillation induced by the P term. Increasing this term decreases the magnitude of the oscillations

**How were the final hyperparameters chosen?**

Tuning of the parameters was an iterative process tuning one parameter at a time while watching the video, noting areas on the track where performance could be improved.

First I tuned the P term from a small value ~0.001 until I started getting oscillations while trying to follow the course. Even though I couldn't make it all the way around with just this term, I settled on a range in the 0.1 to 0.2 range.

The next term I tried to introduce was the I term. I quickly came to realize that a small value of I was needed, or almost no value, though I settled on 0.0001 as my coefficient. While debugging I noticed the integrator stayed wound up for most of the lap.

The final term I played with was the D term. I found that I could damp out the oscillation from the P term with increasing D value.

While tuning, I started at a slow speed, throttle = 0.1 to get the final speed to about 10mph. I noticed that on the sharper turns I needed to increase the P value in order to stay on track but also needed to increase the D value to match in order to reduce the oscillatory effect.

I tried to increase speed by increasing throttle to 0.2 to get to a steady state speed of 30mph. For this condition both P and D had to increase in order to have marginally stable response to keep the vehicle on the road

In summary, the tuning was iterative. I would adjust parameters and try to learn the effect of the adjustment on the steering response. My criteria for settling on the final values was in visual check that the vehicle didn't drive off the road and that oscillations were 'minimized'.