PID Control

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1 PID Control Model

A dual PID control system has been implemented. One PID control loop is used to control the **steering**, while the other is used to control the **throttle**
The control equations are given below
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$$steering = -K_p * cte - K_d * \Delta cte - K_i * \sum cte \tag{1.1}$$

where K_p, K_d and K_i are the proportional, differential and the integral coefficients respectively and cte respresents the Cross Track Error.

The throttle control equations are similarly represented by -

$$throttle = throttle_{max} - K_{throttlep} * cte - K_{throttled} * \Delta cte - K_{throttlei} * \sum cte \tag{1.2}$$

The $throttle_{max}$ parameter represents the maximum throttle that can be applied. This parameter is a trade off between speed and control of the system and has been set to 0.7 based on trial and error. A value between 0.6 - 0.9 provides reasonably good results with the car staying within the yellow lines.

2 Coefficient Optimization

The coefficient optimization process uses a (less efficient) variant of twiddle.
The following options were considered before arriving at this conclusion

Option 1 - Use a fixed track (combination of circular and straight line) which would determine the best starting parameters. Unfortunately the motion model of the car is not known as the relationship between throttle and speed in this case (units and exact equations) are not available to the programmer.

If this were known, using a preconceived motion path to determine the best parameters for a particular $throttle_{max}$ would be possible.

Option 2 - Run the twiddle algorithm is stages. Run a full lap with the selected coefficients and then go back and forth between the twiddle algorithm. This is not ideal, for one al coefficients are incremented or decremented in the same cycle which would prevent finding the most optimal solution.
The biggest drawback is that of speed, iterating this over many laps takes up a lot of time.

At each points in the twiddle algorithm where the model needs to be run, the flag is updated so it keeps track of where it was in the twiddle algorithm. Once the lap is complete, it returns back to this spot and continues this algorithm.

A video of the operation of the car is provided at the link below -
`https://www.youtube.com/watch?v=GOBMCOLC7dE&feature=youtu.be`