Hello sir:

The modified code is main.cpp   pid_controller.cpp   pid_controller.h

The code refers to the relevant questions and answers of the Udacity knowledge community (https://knowledge.udacity.com/questions/907328 ,

https://knowledge.udacity.com/questions/852715

)

the simulation screen shot is as follows :

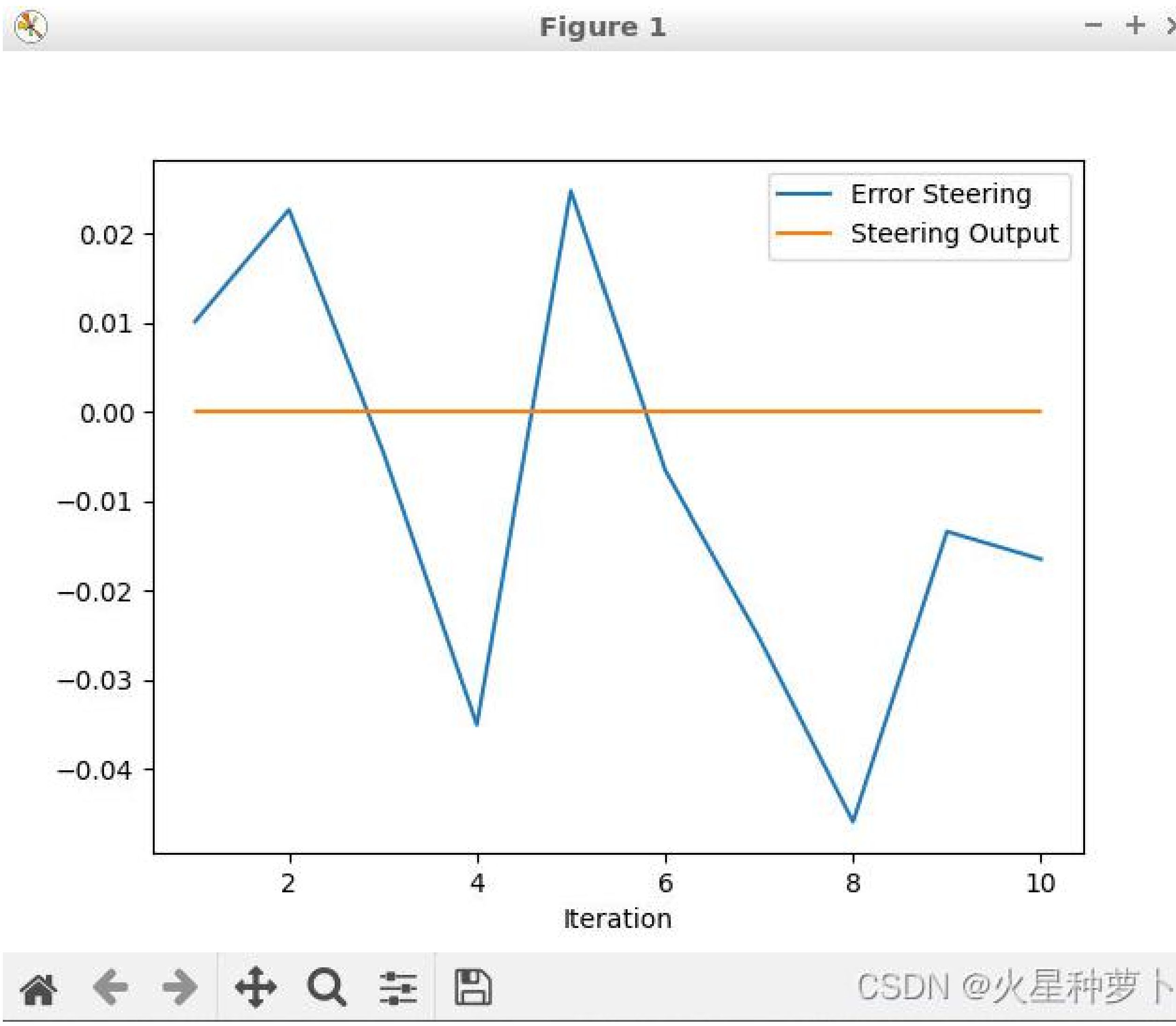
but I can' t see the ego car is moving.

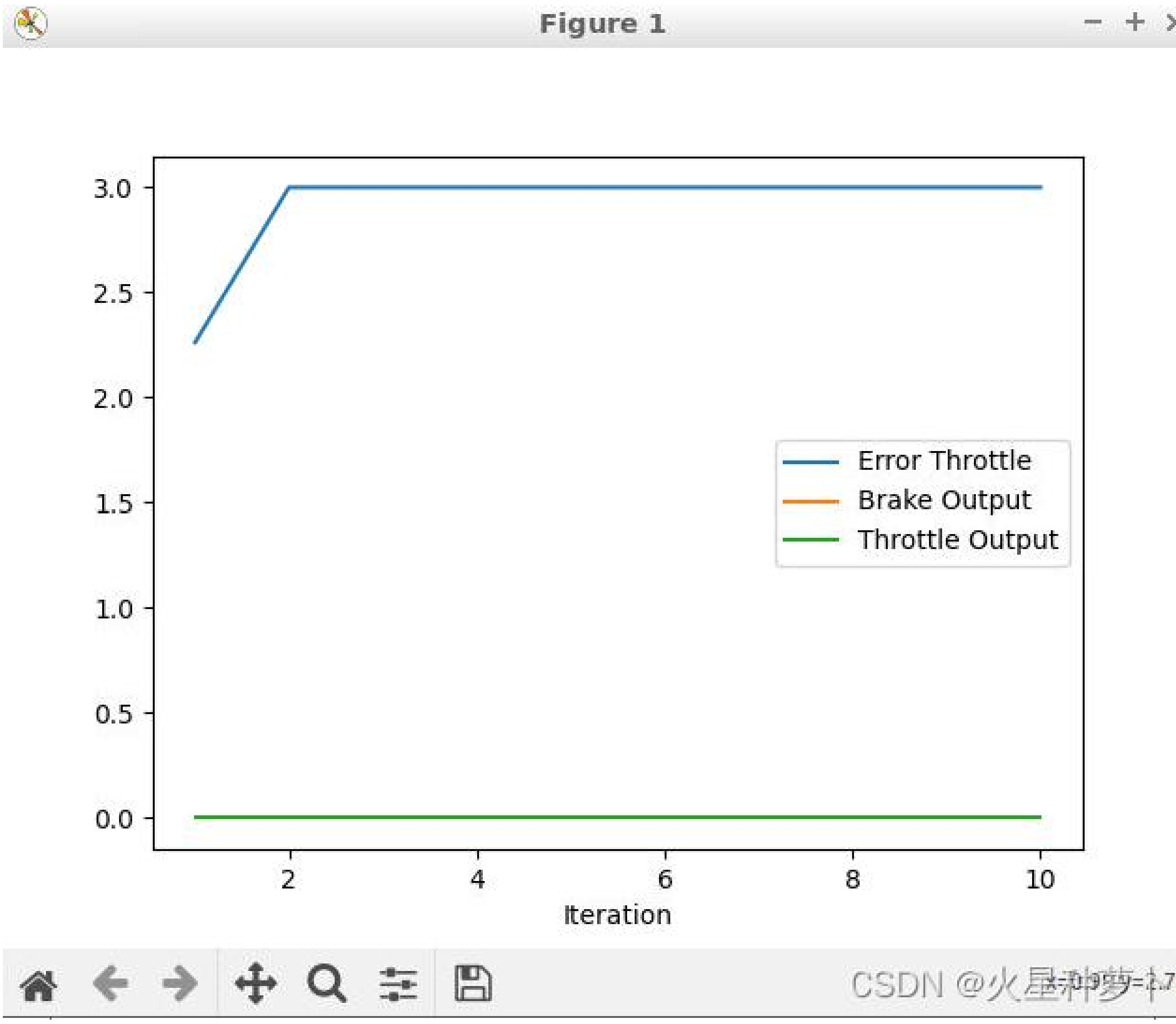
The following are the questions and answers about this PID project submitted:

1 Add the plots to your report and explain them (describe what you see)

(1)The steer_ output oscillation amplitude is large maybe the Kd is smaller.

(2)throttle_output is always 0 no matter how the err_throttle changes.





The raw data is as follows:

Steer data:

- Iteration Error Steering Steering Output
- 0 1 0.010164 1.503320e-154
- 1 2 0.022722 1.503320e-154
- 2 3 -0.004380 1.503320e-154
- 3 4 -0.034995 1.837360e-304
- 4 5 0.024845 1.503320e-154

- Throttle data:
- Iteration Error Throttle Brake Output Throttle Output
- 0 1 2.26167 0 2.667954e-322
- 1 2 3.00000 0 2.667954e-322
- 2 3 3.00000 0 2.667954e-322
- 3 4 3.00000 0 2.667954e-322
- 4 5 3.00000 0 2.667954e-322

2 What is the effect of the PID according to the plots, how each part of the PID affects the control command?

(1)The proportional link reflects the deviation signal of the control system in a timely and proportional manner. Once the deviation is generated, the controller will immediately produce a control effect to reduce the deviation. Generally, with the increase of the value, the overshoot of the closed-loop system increases, and the system response speed increases. However, when the value increases to a certain extent, the system will become unstable.

(2)The integral link is mainly used to eliminate the static error and improve the error free degree of the system. The strength of the integral action depends on the integral constant. The greater the integral action, the weaker the integral action, and vice versa. Generally, under the same condition, the greater the integration effect is, the smaller the overshoot of the closed-loop system is, and the slower the response speed of the system is.

(3)Differential control can reduce overshoot, overcome oscillation, improve the stability of the system, speed up the dynamic response of the system, reduce the adjustment time, and improve the dynamic performance of the system.

When PID control is applied, the proportional amplification factor KP, integral time TI and differential time TD must be properly adjusted to make the whole control system have good performance.

3 How would you design a way to automatically tune the PID parameters?

TWIDDLE, the concrete TWIDDLE tune steps are as follows:

1. Take the original P as the center point, and search the length of each dp step on the left and right to find the best value along coordinate axis to make the value of cost err becomes smaller. If such a value can be found in a certain direction (left or right), the adjustment step becomes larger: dp [i] * 1.1. If the right side cannot be found, find it on the left side of the original P, and repeat the above steps. If a smaller cost_value than the current cost_value can be found, the next two actions (1) update best_err (2) Expand the search step length (dp [i] * 1.1)

2. If none of the above 1 can be found to make the err smaller than the current best cost, go back to the original initial value p [i] of the origin, narrow the search step: adjust it to dp [i] * 0.9, and then continue to search right and left until the exit condition sum (dp)<threshold (usually a small value, such as 0.00001) is reached

The summary is as follows:

The parameters are adjusted from left to right along coordinate axis. Only one generation of parameters (referring to the three parameters p [i] of PID in the same era) is adjusted for each iteration until the conditions for stopping iteration are met. Only one parameter of each property (the specific PID of the same era) is adjusted each round, and certain parameters (such as the gain parameter of P) are not adjusted for many iteration at one time . This may be to prevent falling into a narrow local optimization, without overall consideration of the coordinated adjustment of the three parameters of PID.

4 PID controller is a model free controller, i.e. it does not use a model of the car. Could you explain the pros and cons of this type of controller?

Advantages of PID controller

PID controller has become the most widely used controller, which has the following advantages:

1) PID algorithm contains the main information of the past, present and future in the dynamic control process, and its configuration is almost optimal. Among them, the proportion (P) represents the current information, which can correct the deviation and make the process react quickly. Differential (D) has a leading control function when the signal changes, representing future information. Force the process at the beginning of the process, reduce overshoot at the end of the process, overcome oscillation, improve the stability of the system, and speed up the transition process of the system. The integral (I) represents the information accumulated in the past, which can eliminate the static error and improve the static characteristics of the system. If the three functions are properly coordinated, the dynamic process can be fast, stable and accurate, and good results can be obtained.

2) PID control has good adaptability and strong robustness, and can be applied to various industrial occasions to varying degrees. It is especially suitable for the process control objects of "first order inertial link+pure delay" and "second order inertial link+pure delay".

3) PID algorithm is simple and clear, each control parameter is relatively independent, and the selection of parameters is relatively simple, forming a complete design and parameter adjustment method, which is easy for engineering technicians to master.

4) According to different requirements, PID control has made many improvements for its own defects, forming a series of improved PID algorithms. For example, in order to overcome the high frequency interference caused by differential, the filtered PID control; PID integral separation control to overcome saturation overshoot in case of large deviation; Variable gain PID control to compensate the nonlinear factors of the control object. These improved algorithms have achieved good results in some applications. At the same time,

with the development of intelligent control theory, many intelligent PID control methods have been formed.

Disadvantages of pid controller

To sum up, the defect of PID is that the signal processing is too simple to give full play to its advantages. Specifically, there are four aspects:

(1) The error generation method is not reasonable to control the target v to "jump" in the process, but the change of the controlled object's output Y has inertia, so it is impossible to jump. It is required to let the slowly changing variable y track the variable v that can jump. The initial error is large, which is easy to cause overshoot, which is unreasonable.

(2) There is no good way to generate the differential signal of error. Because the differentiator cannot be realized physically, it can only be realized approximately.

(3) The introduction of error integral feedback has a lot of negative effects on PID control. The role of error integral feedback is to eliminate static errors and improve the accuracy of system response. But at the same time, the introduction of error integral feedback makes the closed loop slow, easy to produce oscillation, and easy to produce control quantity saturation caused by integral saturation.

(4) Linear combination is not necessarily the best combination mode. The control quantity given by PID controller is the linear combination of the present, past and future of the error. A large number of engineering practices show that linear combination is not necessarily the best combination method, and it is worth exploring whether to find a more appropriate combination method in the nonlinear field.

The summary is as follows:

PID control method is simple and easy to implement in engineering, but it has overshoot problem and is not competent for multi-objective constrained optimization of complex control systems with multiple inputs and outputs (MIMO); In theory, MPC can achieve optimal control performance and easily meet the challenges of MIMO systems, but its performance depends heavily on the accuracy of prediction models

5 (Optional) What would you do to improve the PID controller?

The PID controller is not "forward-looking": all quantities involved in the calculation, including the current, the last control cycle, and all previous cumulative sums, have no future.I’d like try MPC controller Algorithm to improve the PID controller.