Vehicle Steering Control

Topics Covered

- Basic data gathering using LabVIEW™
- PD position control of a DC motor

Prerequisites

- The QUBE-Servo 2 has been setup and tested. See the QUBE-Servo 2 Quick Start Guide for details.
- Inertia disc load is on the QUBE-Servo 2.
- You are familiar with the basics of LabVIEW™.

Note: This workbook contains a single independent laboratory experiment as an introduction to the QDS platform. If you are interested in the complete QDS platform, please contact info@quanser.com

1 Background

1.1 Quanser® HIL Driving Simulator

The QUANSER® HIL Driving Simulator (QDS) is a modular and expandable SIMULINK® model of a car driving on a closed track. The model is intended as a platform for the development, implementation and evaluation of a variety of control systems. The QDS consists of a variety of components that are integrated together to create a representation of a vehicle being driven on a track. One possible configuration is shown in Figure 1.1. The model utilizes the QUANSER RAPID CONTROL PROTOTYPING TOOLKIT® environment to facilitate hardware-in-the-loop interfacing (HIL). The QUANSER® Visualization block is also used to create an immersive visual environment for testing and evaluating controllers. Students are expected to observe and think critically about the effects of system parameters on not just the discrete plant, but the overall system.

Figure 1.1: QUANSER® Driving Simulator

Some examples of the real-world control problems that can be addressed using the QDS include parking assist systems, radar guided cruise control, active suspension, traction control and autonomous navigation.

1.1.1 Assisted Steering

Power steering systems have been used for years as a driver aid on production vehicles to make steering easier and safer. More recently, manufacturers have begun to increasingly intervene in the steering process to vary the sensitivity of the steering as a function of the speed of the vehicle. Though true steer-by-wire systems are not available in production automobiles for safety reasons, they are sometimes used in heavy construction or for parking assist systems such as the Toyota Intelligent Parking Assist System.

1.1.2 DC Motor Position Control

For this laboratory, you will use the QDS in conjunction with a Qube Rotary Servo to develop a PD position controller to regulate the steering angle of the simulated vehicle. The controller that you will design takes the steering angle command from the internal driving controller, and the actual steering angle from the Qube encoder signal. The PD controller then outputs the appropriate motor voltage, V_m, to actuate the Qube motor. A block diagram of the overall system is shown in Figure 1.2.

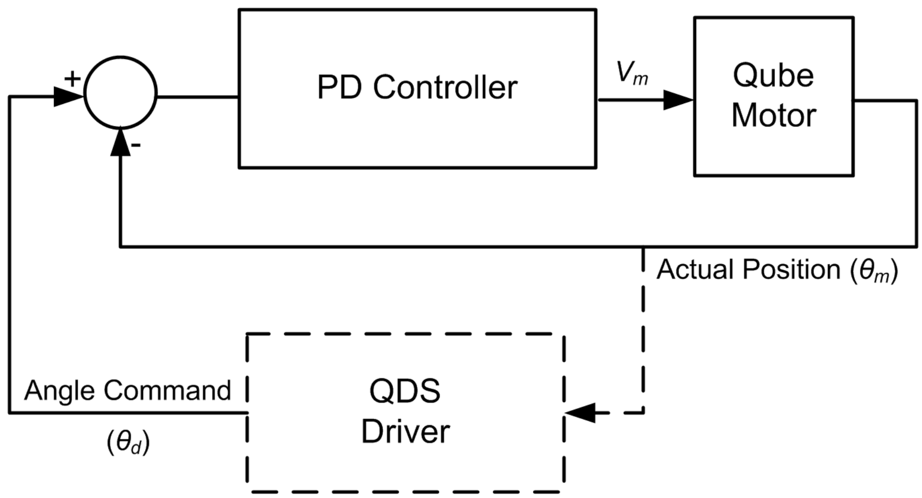

Figure 1.2: QDS steering angle controller

1.2 Background

1.2.1 PD Control

The PD controller is one of the most common control algorithms. For position control, it combines the error reduction of proportional control, with the overshoot elimination of derivative control. The proportional control term tracks the instantaneous error, while the derivative term predicts the response of the system based on the slope of the response. Though the derivative control term is able to reduce overshoot and improve the settling time, the system can be susceptible to steady-state error.

The linear behavior of a PD controller in the time-domain can be described by:

$$u(t) = k_p(r(t) - y(t)) + k_d\left(\frac{d}{dt}r(t) - \frac{d}{dt}y(t)\right) \tag{1.1}$$

where u(t) is the control signal, r(t) is the reference, and y(t) is the measured process output.

2 In-Lab Exercise

1. Open the Quanser Driving Simulator model *Quanser Driving Simulator - Steering.vi*.
2. Open the *Steering Control* subsystem.

   Note: Ensure that the *Input Gain* block is set to 1 and the *DAQ* gain is set to $\pm$10 V

3. Navigate to the main block diagram.

   Note: Ensure that the *Steering Gain* block is set to -1.

4. Set the Kp and Kd controls on the front panel to $k_p = 5$ and $k_d = 0.25$, respectively.
5. Run the VI.
6. Observe the performance of the car as it makes a lap of the track.
7. Is the controller able to track the desired steering angle effectively?
8. What changes could be made to the controller architecture to improve the performance of the steering controller?
9. If necessary, retune the controller gains to achieve the desired performance.
10. Record the final control gains and response plots.
11. What other applications could a similar system have in the real world?

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