Data-driven system identification for model-based speed control design

Let us assume that we are in October 2026.

You are just graduated from Polytech Nancy and you work for a company as a Control Engineer.

Your first project is to answer an industrial customer who requests from your company a rotary speed control of a DC motor that will actuate a new robot arm which is programmed to move at a given speed when performing a task such as welding or painting.

Here we investigate the model-based rotary speed control for the Qube-Servo 2 platform equipped with the inertia disk, as shown in Figure 1.1, that was used during one of the labs last year.

Figure 1.1: Qube-Servo 2 platform equipped with the inertia disk

The input of the system to be controlled is the voltage of the motor in V while the output is the angular velocity or rotary speed in rad/s.

By working in group of 2 students, the goal of this lab is to determine a mathematical model of the Qube-Servo 2 from recorded input/output data that will be used to design a rotary speed control. The workflow is illustrated in Figure 1.2.

You are free to use any identification and control methods you like.

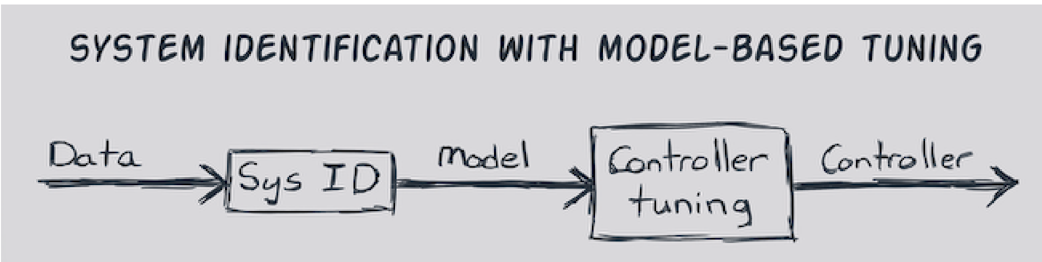

Figure 1.2: From Data to Model to Controller

The general methodology for the design of a feedback control is detailed in Figure 1.3[1].

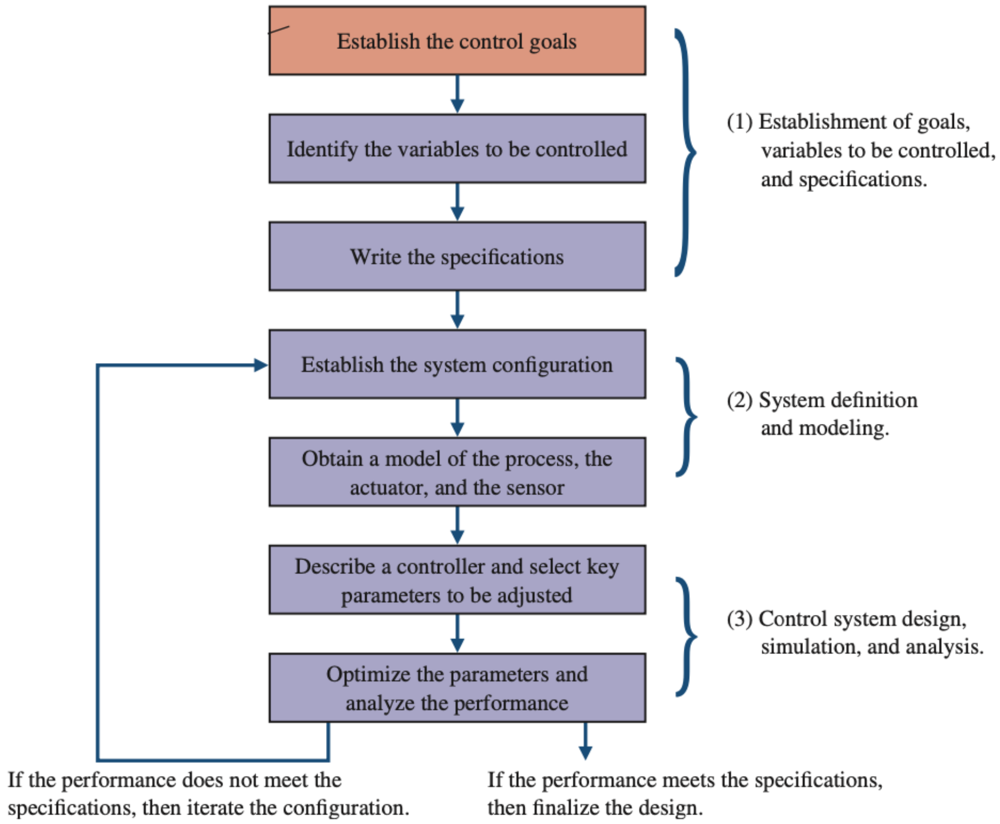

Figure 1.3: The control system design methodology

From Figure 1.3, the controller design problem can be summarized as follows:

Given a model of the system (including its actuators and sensors) to be controlled and a set of performance specifications, find a suitable controller (or determine that none exists!).

As with most of engineering design, the design of a feedback control system is an iterative process as shown in Figure 1.3.
A successful designer must consider the underlying physics of the plant under control, the control design strategy, the controller design architecture (that is, what type of controller will be employed), and effective controller tuning strategies.
One key stage in the model-based control system design methodology is to obtain a model of the dynamical system.

The lab is first designed to make you reflect on the following practical aspects of the system identification workflow:

1. How to collect data: choice of the excitation input to be sent to the Qube, choice of its amplitude, choice of the sampling period, choice of the time duration of the experiment ?
   Download the Simulink and Matlab files that will allow you to apply to the Qube the chosen motor voltage and record the angular velocity.

2. How to choose a suitable structure for the model ?

3. How to estimate the parameters of the chosen model structure from the collected data ?
   Use the different measured signals (input data, angular velocity and acceleration data) to build up the regression matrix and output vector to implement your own Least Squares first-order transfer function

[1] From Richard Dorf and Robert Bishop, Modern Control Systems, Pearson, 2022

model parameter estimates. Look in the .m how the procsrivc.m routine from the CONTSID toolbox can be used to directly and easily estimate the first-order transfer function model.

4. How to validate/evaluate the quality of the model ?

5. How to use the model to design a control to meet the performance specifications?

Once you have a good identified model, define a set of performance specifications and find a suitable controller of the PID family. Use the provided files to test in simulation first the performance and then implement it on the Qube Servo 2.