Introduction to System Identification

Contents map

developed content units	taxonomy levels
system identification	u1, e1
parameter estimation	u1, e1
least squares	u1, e1

prerequisite content units	taxonomy levels
impulse response	u1, e1

Main ILO of sub-module "Introduction to System Identification"

describe the underlying concepts behind system identification

describe the role of system identification in model-based control

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in a nutshell: to build mathematical models of
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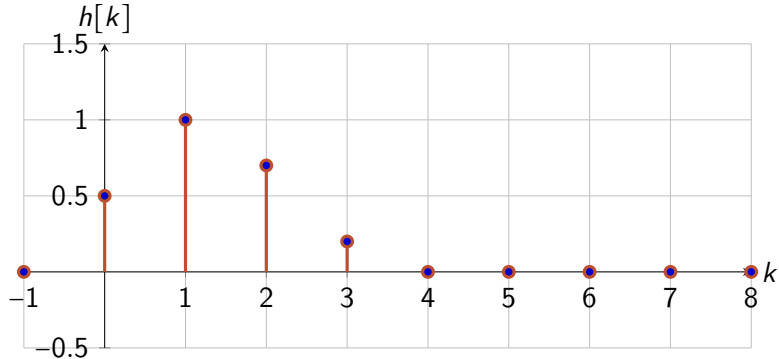
Typical ingredients:

- measurements (inputs and outputs)
- model structure (e.g., impulse response).

Identification in this course

focus on estimating the coefficients
that define the impulse response
of causal FIR discrete-time LTI systems
(likely less than 1% of what sysid encompasses)



More precisely

$$\text{available dataset: } \mathcal{D} = \{y[k], u[k]\}_{k \in \mathcal{K}}$$

$$\text{assumed model: } y[k] = \sum_{i=0}^{n} h[i]u[k-i] + e[k]$$

with

- n to be estimated
- $h[0], h[1], \ldots, h[n]$ to be estimated
- $e[k]$ noise / modeling error with potentially unknown statistics

Does identification matter for control?

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Does identification matter for control?

. . . how can you do model-based control without a model? Caveats, though:

- end goal of this course = MPC
- bad model $\implies$ bad model based controller
- bad dataset $\implies$ bad model *(filtering may help!)*

Next modules

- least squares
- regularization

Summarizing

describe the underlying concepts behind system identification

describe the role of system identification in model-based control

- need a model structure
- need input-output data
- need an estimation algorithm

Most important python code for this sub-module

A very widely used library

https://scikit-learn.org/stable/

Self-assessment material

Question 1

Why do we need system identification before applying model-based control techniques like MPC?

Potential answers:

I: To make the system faster
II: To reduce noise in sensors
III: To estimate a model of the system from data
IV: I do not know

Question 2

What is the primary purpose of system identification in control engineering?

Potential answers:

I: To increase the processing speed of the control system
II: To construct a mathematical model of a dynamic system using data
III: To eliminate measurement noise entirely from sensors
IV: To design the controller directly without requiring a model
V: I do not know

Question 3

Why is input-output data critical in system identification?

Potential answers:

I: To determine the physical dimensions of system components
II: To estimate model parameters that best explain the observed behavior
III: To validate the controller's performance in real-time
IV: To replace the need for mathematical modeling entirely
V: I do not know

Question 4

What is a major risk of using a poorly identified model in Model Predictive Control (MPC)?

Potential answers:

I: The system's hardware may suffer physical damage
II: The controller may perform inadequately due to inaccurate predictions
III: Increased computational load during controller operation
IV: The need for more frequent sensor calibrations
V: I do not know

Question 5

Which three elements are fundamentally required for system identification?

Potential answers:

I: Actuators, sensors, and a power supply
II: Controller design, simulation software, and data storage
III: Input-output data, estimation algorithm, and if available, model structure
IV: Noise filters, feedback loops, and setpoints
V: I do not know

Recap of sub-module "Introduction to System Identification"

- Model-based control requires accurate models
- System identification builds models from data
- There are several tools to estimate model parameters, in this course we only scratch the surface

?