Advanced Motion Control

Experimental instruction: Iterative Learning Control

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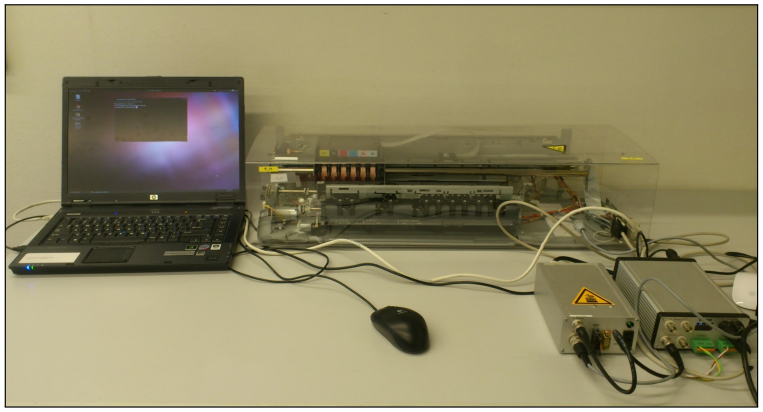
Organization

Some practical notes:

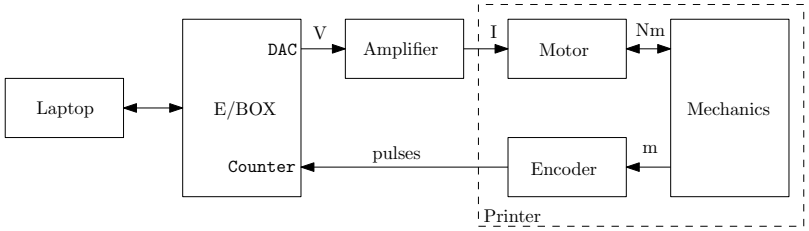
- Registration list for experiments at entrance of DCT-lab
- Location DCT-lab: GEM-Z -1.13 (near room -1.138)
- 3 setups available
- Groups of two persons (also for oral exam)
- Time slots of 3 hours (three each day)
- Subscribe for one timeslot at a time (expected: only need 1)
- Laptops are provided with Ebox Ubuntu installed (don't forget to bring a USB stick)
- **Prepare your experiments:** first perform simulations
- Manual/Matlab/Simulink files: CANVAS

The printer setup



The printer setup

Setup topology:

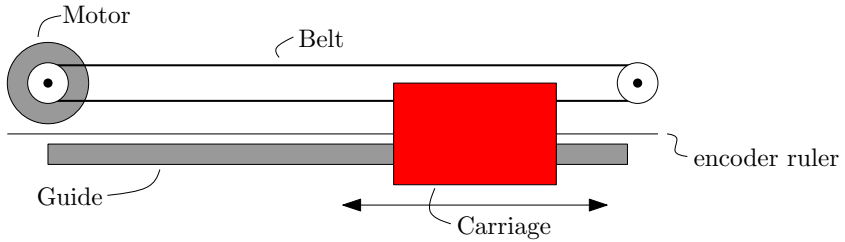


Properties:

- E/BOX provides Input-Output to the laptop
- Controller runs in real-time on the laptop

Modeling the printer setup

Schematic overview:

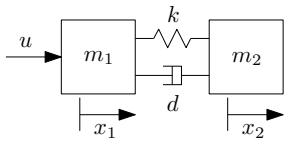


Specifications:

- Motor is current controlled, input range ± 2.5 V
- Carriage position is measured by a 600 CPI optical encoder

Modeling the printer setup

Given model:



Variables:

- u, motor torque
- x_1, motor position (not measured in the physical setup)
- x_2, carriage position

Equations of motion:

$$m_1\ddot{x}_1 = k(x_2 - x_1) + d(\dot{x}_2 - \dot{x}_1) + u$$
$$m_2\ddot{x}_2 = k(x_1 - x_2) + d(\dot{x}_1 - \dot{x}_2)$$

Modeling the printer setup

Physical parameters:

$$m_1 = 1.0 \cdot 10^{-3} \text{ kg}$$
$$m_2 = 8.5 \cdot 10^{-2} \text{ kg}$$
$$k = 1.6 \cdot 10^{2} \text{ Nm}^{-1}$$
$$d = 8.7 \cdot 10^{-2} \text{ kgs}^{-1}$$

The model in state space form:

$$\dot{z} = Az + Bu$$
$$y = Cz + Du$$

with state $z = \begin{bmatrix} x_1 & \dot{x}_1 & x_2 & \dot{x}_2 \end{bmatrix}^T$
and output $y = x_2$

Modeling the printer setup

With:

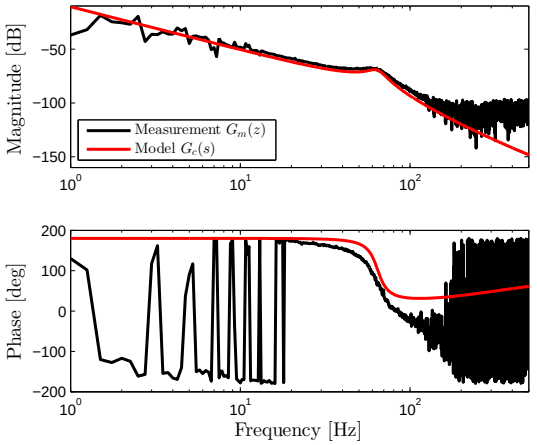
$$A = \begin{bmatrix} 0 & 1 & 0 & 0 \\ -m_1^{-1}k & -m_1^{-1}d & m_1^{-1}k & m_1^{-1}d \\ 0 & 0 & 0 & 1 \\ m_2^{-1}k & m_2^{-1}d & -m_2^{-1}k & -m_2^{-1}d \end{bmatrix}$$
$$B = \begin{bmatrix} 0 & m_1^{-1} & 0 & 0 \end{bmatrix}^T$$
$$C = \begin{bmatrix} 0 & 0 & 1 & 0 \end{bmatrix}$$
$$D = 0$$

Transfer function $y = G(s)u$:

$$G(s) = \frac{ds + k}{m_1 m_2 s^4 + d(m_1 + m_2)s^3 + k(m_1 + m_2)s^2}$$

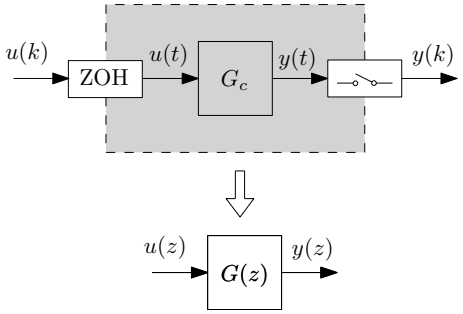
Modeling the printer setup

Frequency response measurement and continuous time model:



Modeling the printer setup

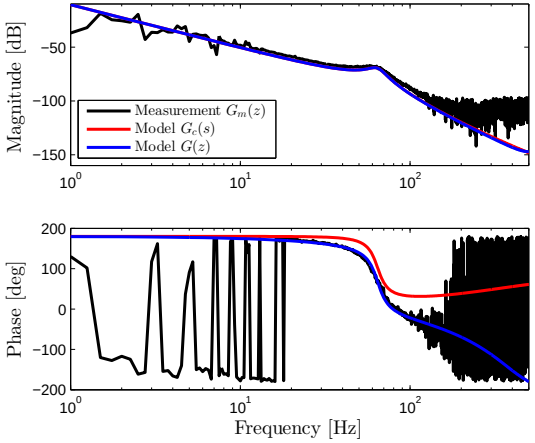
Sampling and holding:



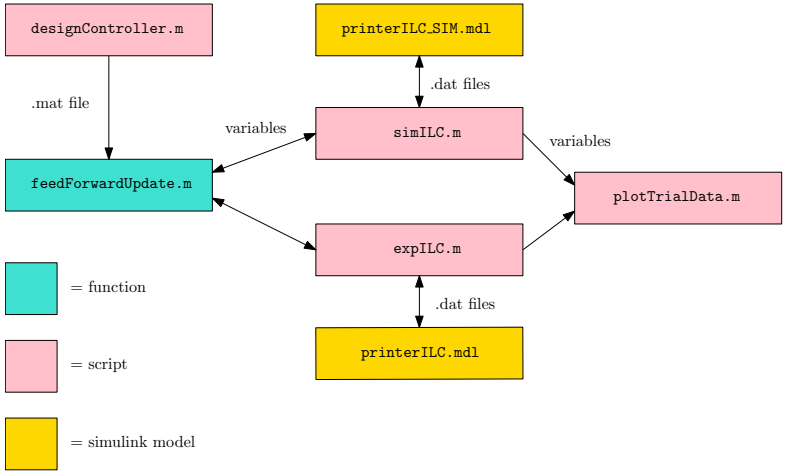
In matlab using “c2d(Gc,Ts,‘zoh’)", see Franklin et al. (2008)

Modeling the printer setup

Frequency response measurement and discrete-time model:



Software overview



Software overview

Used software:

- Ebox Ubuntu
- Matlab \ Simulink
- Same software used in 4CM00: Control Engineering

See the experiments manual for:

- experiments organization
- installation procedure (or how to update existing installation)
- how to start experimenting
- frequently asked questions

Questions?

Demonstration

Demo!

References I

Franklin, G., Powell, J. & Emami-Naeini, A. (2008), *Feedback Control of Dynamic Systems*, Pearson.