Homework 3 in EL2450 Hybrid and Embedded Control Systems

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Instructions and Help

Please remove this part and the sample references before submitting your homework.

Read the general homework instructions available on the course homepage before starting to write the report.

Here are some additional guidelines how to write a homework report.

- Fill in name and personal number of all group members.
- Do not copy the task descriptions and use the structure below.
- Do not include code unless the task explicitly states so.
- Motivate your answers well and how you derived them, but be concise.
- The number of points is not necessarily related to much you need to write for task.
- Put references in the end if any.
- Do not include plots from the Simulink scope (color on black background) but export the data to Matlab for plotting.
- Include graphics directly in the text and not in a Figure environment, as you normally would. That makes it easier to correct the report.
- There is plenty of material available how to use Latex. Use a search engine of your choice to learn more.

Here are some examples how to use Latex:

- An equation with a reference (1) to it

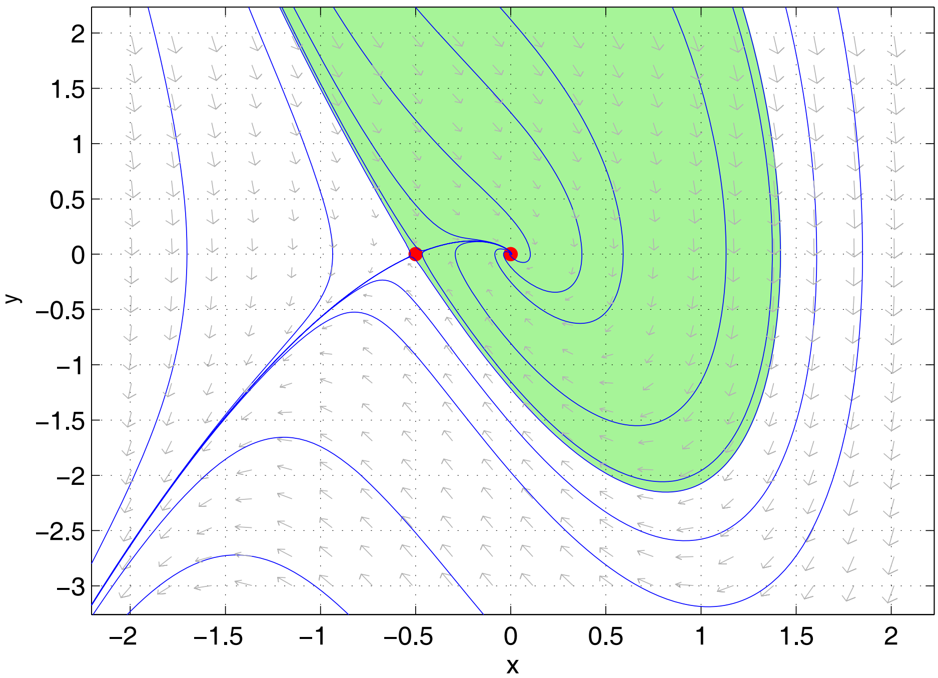
$$\dot{x} = \frac{3}{4}x. \tag{1}$$

- A multi-line equations with a reference to it

$$\hat{x} = x - y$$
$$\alpha = x + \gamma.$$

- An equation in text: $\Phi = \int\limits_0^h \mathrm{e}^{A\tau} d\tau$.

- An image



- A table

-2.46	0	-1.73	0
0	-2.553	0	2.774
0	6.172	-10	7.333
1.767	-0.357	5.714	-6.074

- A citation [2]

- Display something exactly as it is written: `\frac{1}{2}_`

- Basic formating: **bold**, *italics*, `typewriter`

Task 1

$$u_r = \frac{2^{u_\omega + u_\psi}}{2} = u_w + \frac{u_{Psi}}{2} \tag{2}$$

$$u_l = u_\omega - \frac{u_\Psi}{2} \tag{3}$$

Task 2

By calculating the mean value of $\dot{x}$ from the data in *Forward.cvs* R could be estimated with equation (4)

$$\dot{x} = R * u_\omega * cos(\theta) \tag{4}$$

By calculating the mean value of $\dot{\theta}$ from the data in *Rotate.cvs* L could be estimated with equation (5)

$$\dot{\theta} = \frac{R}{L} u_\Psi \tag{5}$$

The estimated values are

R	L
111	111

Task 3

$\dot{\theta} = R/Lu_\psi$ won't be asymptotically stable due there is no condition without an input signal. It will not have Zeno behaviour due there is no finite time limit. The system will continuously oscillate around zero.

$\dot{\theta} = R/Lu_\psi$ will be asymptotically stable due to no limitations on the input signal. SKRIV NÃ...GOT

Task 4

The system is asymptotically stable due to we can let the hold time go to zero which is not possible in real life. SKRIV OM ZENON

Task 5

The system is stable but not asymptotically stable due to the use of a controller with a zero-order hold. The continuously oscillatory behaviour indicates that there is no Zeno behaviour.

Task 6

The discretized system can be seen in Equations (6),(7) and(8)

$$\frac{z-1}{T_s} x[k] = Ru_\omega[k] cos(\theta[k]) \tag{6}$$

$$\frac{z-1}{T_s} y[k] = Ru_\omega[k] sin(\theta[k]) \tag{7}$$

$$\frac{z-1}{T_s} \theta[k] = \frac{R}{L} u_\Psi[k] \tag{8}$$

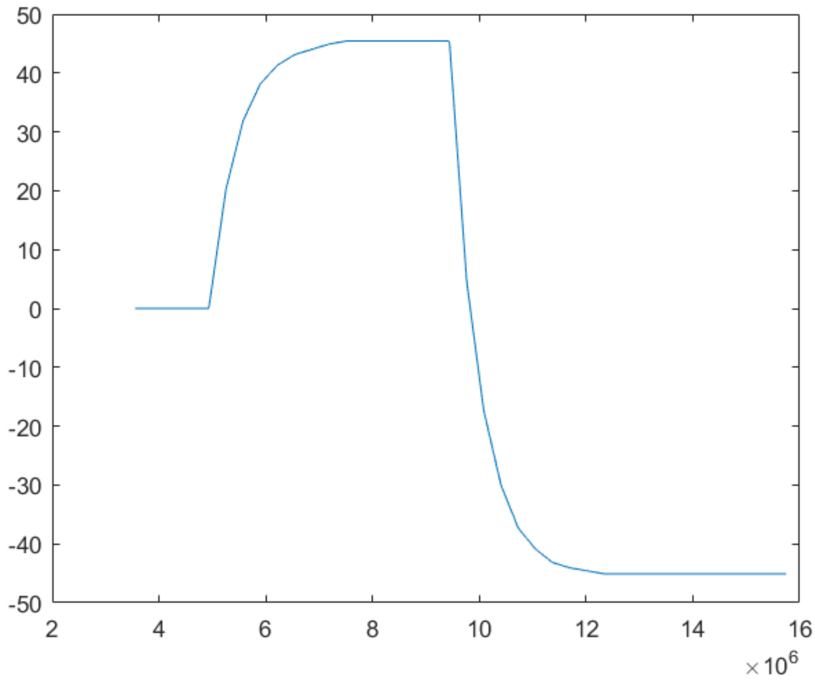
Task 7

Solution to the task

Task 8

It is not possible to reach the goal angle due to we only have a proportional controller and therefore always have a small static error.

K = 0.7*L/R



Task 9

With euler forward method we have that

$$\theta[h] \approx \theta[k] + \dot{\theta}[k]\tau_s$$

We have $\dot{\theta}$ from equation (3) and control signal u_Ψ in the assignment. This give the following equation for the system.

$$\theta[k+h] \approx \frac{RK_\Psi\tau_s(\theta^R - \theta[k])}{L} + \theta[k]$$

$$\theta[k+h] \approx (1 - \frac{RK_\Psi\tau_s)}{L})\theta[k] + \frac{RK_\Psi\tau_s)}{L}\theta^R$$

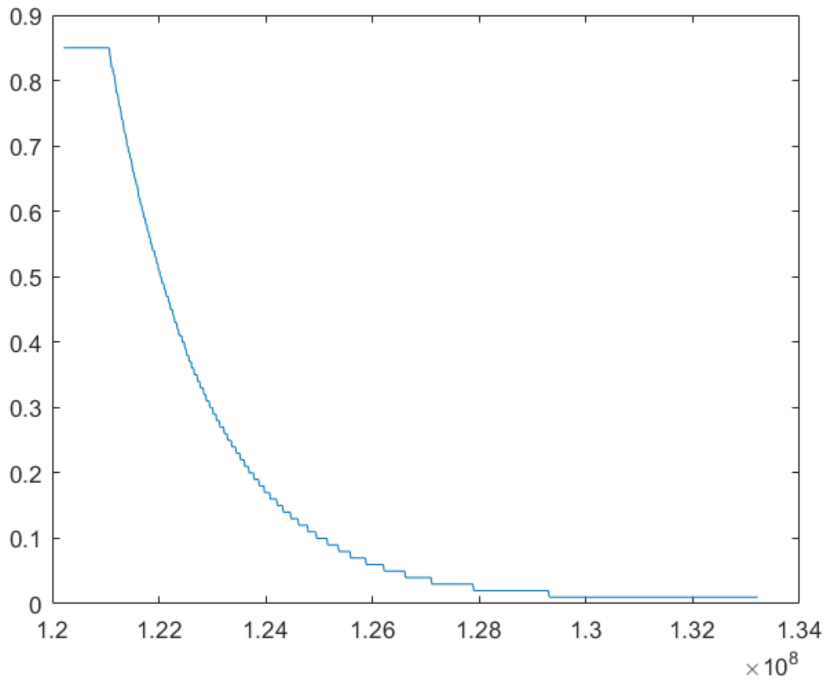
This is stable i the absolute value of the eigenvalues are less than 1 for the Φ matrix. The eigenvalue is

$$\lambda = |1 - \frac{RK_\Psi\tau_s)}{L}| < 1$$

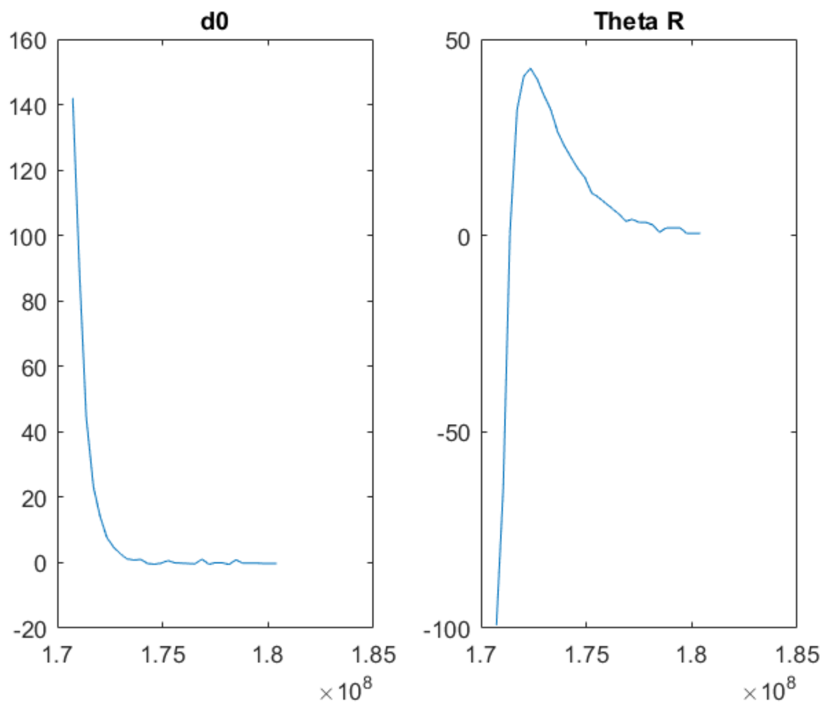
This gives the the upper/lower boundary of $0 < K_\Psi < \frac{2L}{R\tau_s}$.

Task 10

K = 5 In the general case no due to the direction of the robot is not lined up with the point it wants to go to.



Task 11

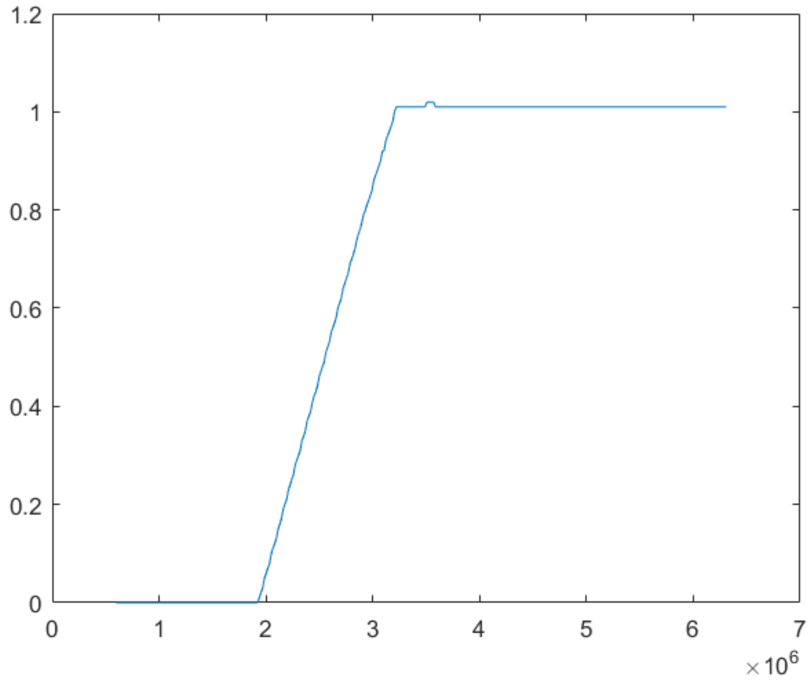


Task 12

Solution to the task

Task 13

K = 30



Task 14

Solution to the task

Task 15

Solution to the task

Task 16

Solution to the task

Task 17

Solution to the task

Task 18

Solution to the task

Task 19

Solution to the task

Task 20

Solution to the task

Task 21

Solution to the task

Task 22

Solution to the task

References

[1] Hassan K Khalil. *Nonlinear systems.* Prentice Hall, Upper Saddle river, 3. edition, 2002. ISBN 0-13-067389-7.

[2] Tobias Oetiker, Hubert Partl, Irene Hyna, and Elisabeth Schlegl. *The Not So Short Introduction to LaTeX 2ε.* Oetiker, OETIKER+PARTNER AG, Aarweg 15, 4600 Olten, Switzerland, 2008. http://www.ctan.org/info/lshort/.

[3] Shankar Sastry. *Nonlinear systems: analysis, stability, and control*, volume 10. Springer, New York, N.Y., 1999. ISBN 0-387-98513-1.