Modeling and Learning for Dynamical Systems

Lecture 12

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Exam Question Example

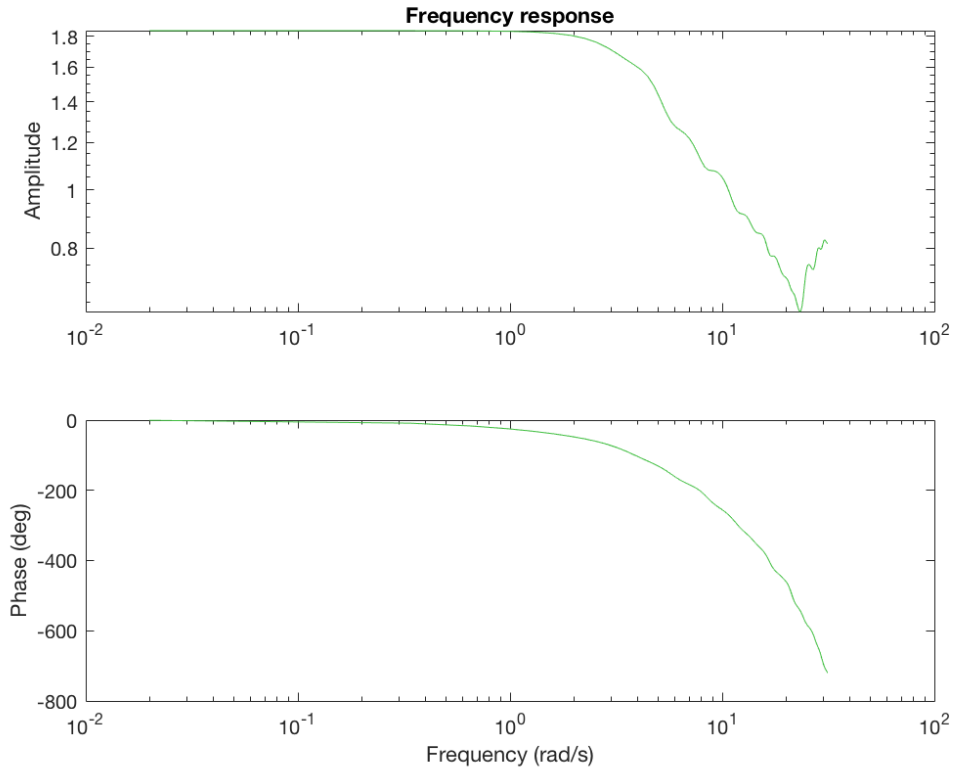
Example

The data for this exercise are in a file called `sysid_data_20211029.mat`. To load it into your Matlab workspace type `load sysid_data_20211029.mat` at the Matlab prompt. Inside `sysid_data_20211029.mat` you will find the sampled signals u and y (the sample time is $T_S = 0.1\,\text{s}$).

(a) Do the data show any sign of resonances? [2p]

Example...

Answer to (a): There are no signs of resonances, see the frequency function below, computed with SPA (M=100).



Example...

(b) Construct one or more appropriate black-box models fitting the data, with the constraint that the total number of poles in the input-output transfer function is less or equal to 3 (i.e., $n_a \leq 3$ for ARX and ARMAX, $n_f \leq 3$ for OE and BJ). Report:

- plot of the model's simulated output vs. the measured output for validation data
- parameter values and uncertainties
- residual plot
- Bode plot
- poles and zeros placement

Discuss and comment your choices and results. [8p]

Example...

Answer to (b): The ARX order selection tool suggests a delay $n_k = 3$. Keeping this delay, a model that satisfies the constraint of max 3 poles is for instance the following OE(2,3,3):

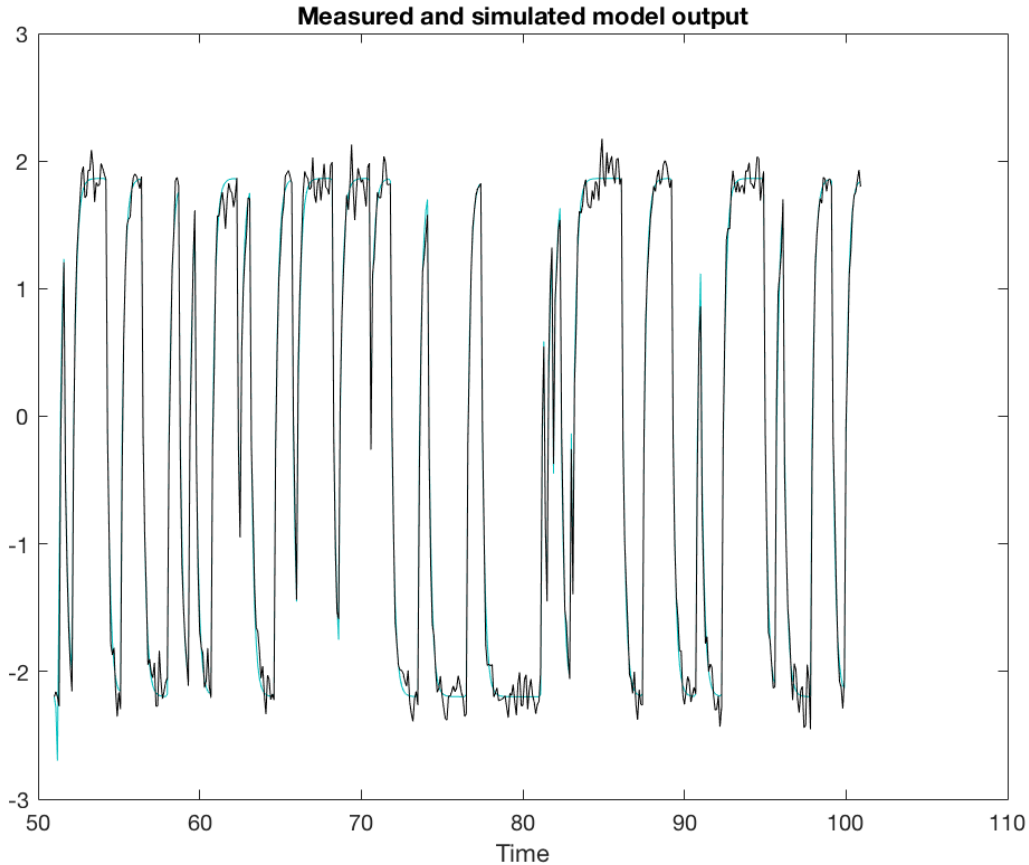
```
oe233 =
Discrete-time OE model:  y(t) = [B(z)/F(z)]u(t) + e(t)

B(z) = 0.008766 (+/- 0.008597) z^-3
       + 0.9868 (+/- 0.01131) z^-4
F(z) = 1 - 0.4045 (+/- 0.01094) z^-1
       - 0.1036 (+/- 0.0141) z^-2
       - 0.001491 (+/- 0.008743) z^-3
```

It provides a fit to validation data of 92.69%.

Parameter uncertainty is reasonably small, although for $B(z)$ the first coefficient is of the same magnitude as the standard deviation (other models with max 3 poles seem to have similar problems).

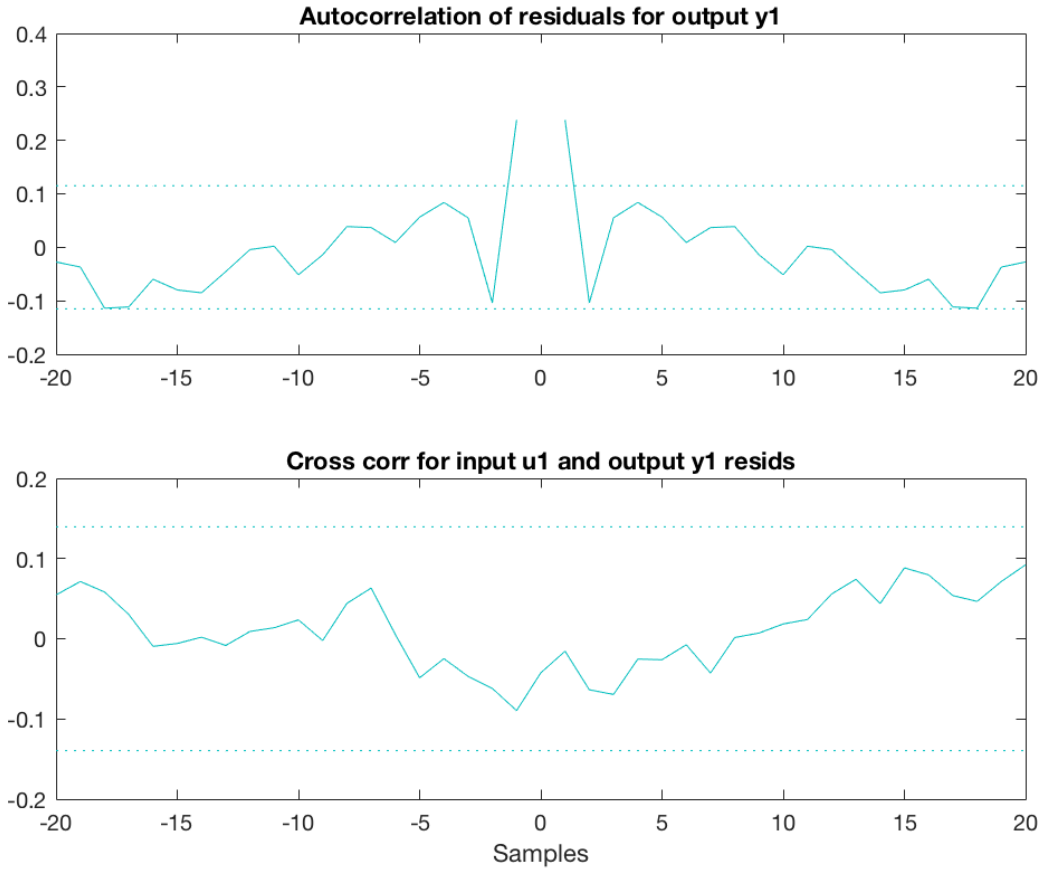
Example...

The simulated model output for validation data is shown below.



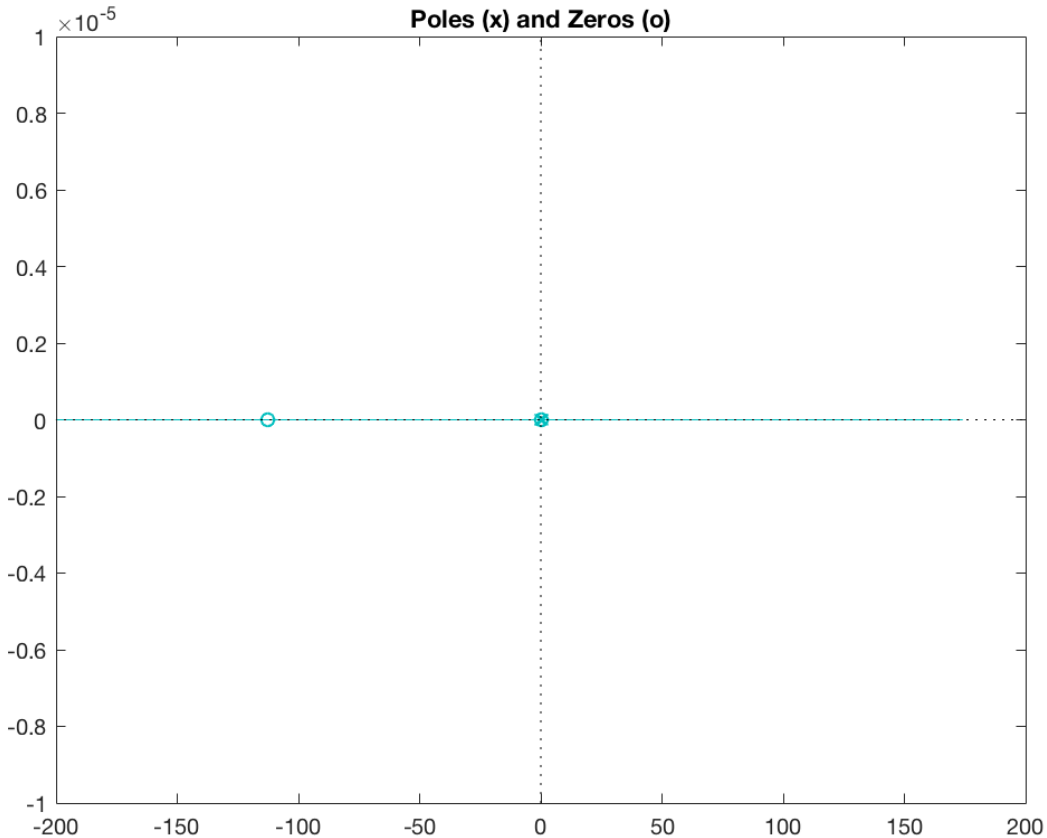
Example. . .

Residual analysis gives the result below.



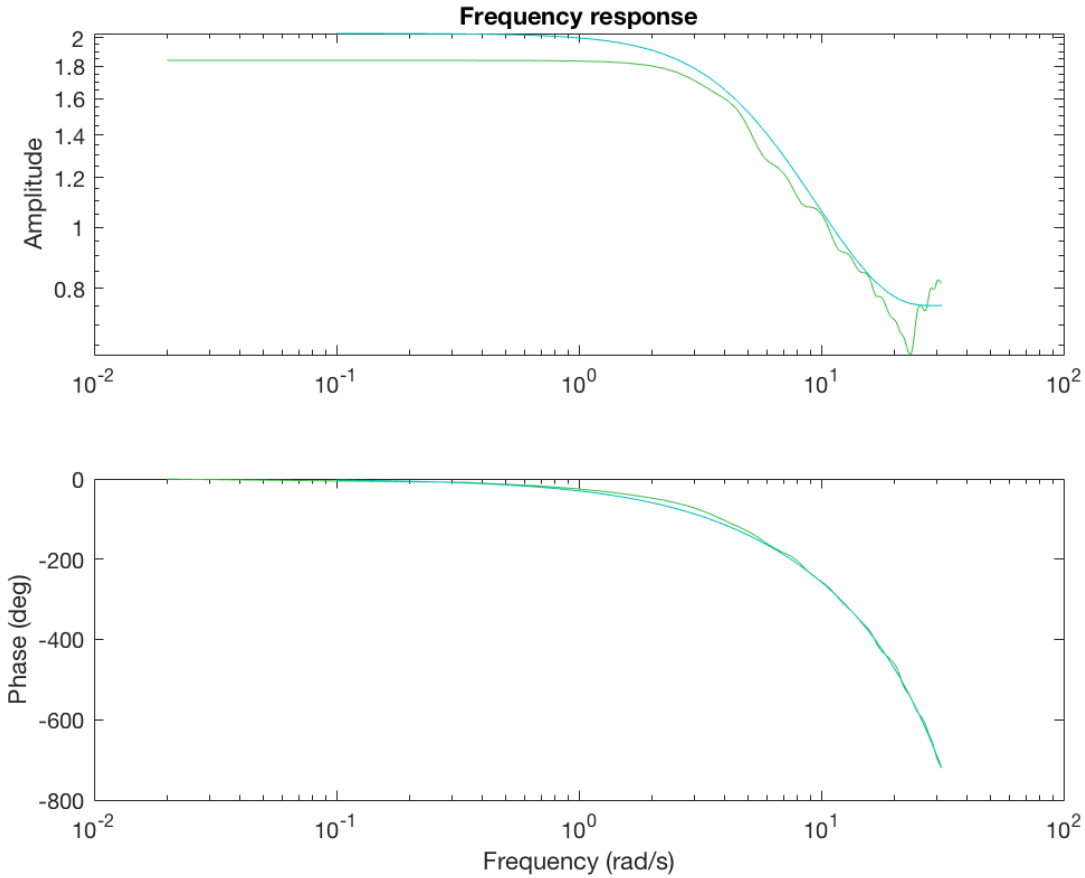
Example...

Zeros/poles are shown below. The poles are all stable. The confidence intervals are not completely disjoint.



Example. . .

The frequency function is similar to the SPA frequency function, see below, except for a difference in the DC gain.



Exam

Exam

- 4h computer exam
- Pass: 23 points (maximum 50)
- Tools:
  - L. Ljung, T. Glad & A. Hansson: *Modeling and Identification of Dynamical Systems*
  - T. Glad & L. Ljung: *Reglerteknik - Grundläggande teori*
  - Any mathematical tables or formula collections
  - Calculator
  - Computer with Matlab
- Normal comments in the books are OK (but not solved exercises)
- No communication with other people during the exam

Exam Advice

- Sign up for the exam!
- Test the computers and printers before the exam
- Save commands in files
- Print files and figures regularly during the exam and make sure to sign all printouts
- Hand in solutions, code, figures even if you believe they are not fully correct
- Show what you can and know, give clear motivations and explanations!

Thanks for your attention!

Good luck with the exam and the rest of your studies!

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