Laboratory Work – 3.0

ESTIMATING LTI MODELS. PART I: IMPULSE RESPONSE MODELS. STEP RESPONSE MODELS

1. Goal of the lab:

To demonstrate the use of the System Identification Toolbox (MATLAB) for estimating LTI models.

2. Introduction

The deterministic process used for demonstration in the transfer function form is:

$$G(q^{-1}) = \frac{0.6 - 0.2q^{-1}}{1 - 0.5q^{-1}} q^{-1}$$

3. Tasks

- **Model development, input signal and measurement noise**

1. Write this transfer function in the difference equation form.
2. Present the process model using ***idpoly*** command (Sampling time = *1 s*) in MATLAB. Specify the noise variance being equal to **1** for the model as well.
3. The input signal (**uk**) is a pseudo-random binary signal ('**prbs**') of length N = 1275 and with the frequency band of *[0 1/5]* and input levels of *[-1 1]*. Use ***idinput*** command.
4. Model noise variance will be 10 times less than the variance of simulated output. Use ***sim*** and ***var*** commands.
5. Simulate the output with the generated input and built model. Add noise to the response of the system as the simulation options. Use ***sim*** command.
6. Collect the input-output data in the ***iddata*** object and ***detrend*** it into the zero-mean data. *Ts = 1 s;*
7. Plot the ***iddata*** object for the samples (1:500).

- **Estimation FIR model**

8. Estimate the impulse response model for the detrended data introduced above (***impulseest***)
9. Estimate 10 impulse response coefficients for this model (***impulse***).
10. ***Stem*** the IR coefficients in a separate figure.
11. Plot the upper and lower thresholds (use the *standard deviation* defined above) to show the insignificant risk of lags for the model.
12. Compute the true values for FIR coefficients and plot them on the same figure. This can be done by using ***filter*** command and coefficients introduced in the transfer function of the process.

- **Estimation of step-response model**

  As with impulse response models, empirical step-response model can be developed by way of estimation from (user-designed) input-output data.

  13. Estimate step response FIR model of the process with the final time of 15 units (***step***).
  14. Plot the estimated step response model for the time interval defined in the model.
  15. Determine the a) gain, b) delay and c) time-constant of the system accordingly.
  16. Compute the step response and plot it on the same figure. This can be done by using ***filter*** command and coefficients introduced in the transfer function of the process.

4. Questions

1. Which are the main functions used for estimation of FIR and step-response models?
2. What information can be extracted from impulse response estimation?
3. What information can be extracted from step response estimation?