Filtering and Identification Practical Assignment 2

The System Identification Cycle

Deadline: 18-01-2021 18:00h

Introduction

In this practical assignment you will use your model estimation code from Matlab Assignment 2 to identify an unknown system by going through the system identification cycle. For this, you need the file `exciteSystem.p`[1], which you can find on Brightspace. You may consider this file as an **unknown black box system**. You can provide an input sequence and a sampling frequency to this system and it will return a corresponding output sequence at the same sampling frequency. You use the file by adding it to your path in Matlab and calling the function

```
y = exciteSystem(STUDENTID,u,fs)
```

Here, `y` is the output sequence y_k of the to be identified system, `STUDENTID` is the **lowest-valued** student-id of the students in the group, `u` is the provided input sequence u_k, and `fs` is the sampling frequency. The system is inherently simulated in discrete time, so there is **no need for you to apply a band-pass filter to prevent anti-aliasing**, as you need to do for analog systems that have been sampled digitally. Your objective is to identify a model for this black box system. Try to determine a model that performs well on both your identification as your validation data set in terms of simulation.

It can be expected that noise spikes will be present in the output. These spikes need to be removed from the data before identifying the system. Your system may also contain a time delay of up to one second. This should also be taken into account before using your identification code.

To complete this assignment, we expect you to go trough the identification cycle, see Figure 1, as many times as needed. Use the `publish` function in Matlab to publish your script —with comments— as a report.

At the end of this document you find the expected format of your script. Make sure that you **clearly motivate each design step**. Hand in one report, as pdf, per group before **18-01-2021 18:00h**

Throughout this practical assignment, remember that the identification cycle is an iterative process and you typically need more than one iteration. Limit your report to the final iteration.

[1] Note that this file requires the `System Identification Toolbox`.

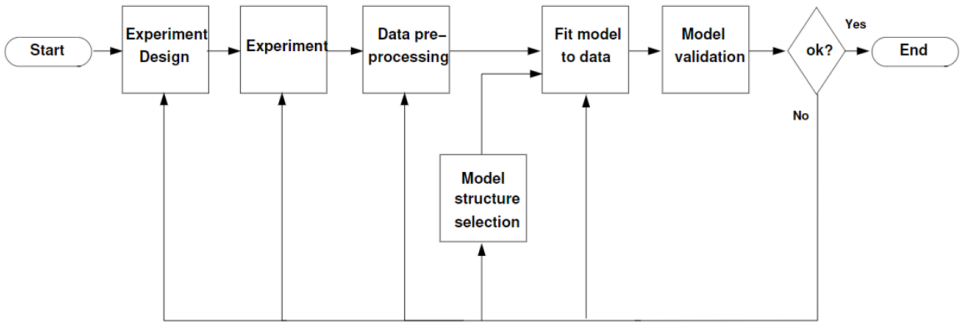

Figure 1: The system identification cycle

Assignment 1: Experiment Design and Data Pre-Processing

The first steps of the identification cycle are to design your experiment and pre-process the input and output data. In this assignment, use the `exciteSystem` function and

- Determine the sampling frequency.
- Provide a persistingly exciting input signal .
- Motivate how you identify and remove spike noise from your data.[2]
- Determine and take into account any time-delays of your system.
- Remove the DC offset from the output.
- Determine whether your system is linear.
- Generate input-output data that you will use for identification and data that you will use for validation.

Assignment 2: Identification

In this assignment you will identify your system. Here, we highly recommend you to use your code from Matlab Assignment 2. It is however **not allowed** to use tools from the `System Identification Toolbox` to identify your system. Furthermore, you are not allowed to use a white-noise sequence as an input signal, since in the real-world this is often not possible. For this assignment

- Determine the model order. Plot the singular values using the `semilogy` command and motivate your choice of order.
- Estimate the model. You are free to choose the estimation method.

Assignment 3: Validation

The final step of the system identification cycle is to validate your model. In this assignment, validate your identified model. In your motivation,

[2]You may use the Matlab function `interp1` to do the interpolation.

- Compare the VAF for the identification data with the VAF for the validation data and discuss.
- Determine the auto-correlation of the residuals and discuss.
- Determine the cross-correlation between the residuals and the inputs and discuss.

Matlab Publish Format

Please format your code similar to the following example

```
%% Filtering & Identification Practical Assignment 2
% Jane Doe #123456
% John Doe #654321
%% Assignment 1
%%% Input signal
% We chose the following input signal because...
% The following plot shows the input signal, you can see that...
u = ones(10,1);

figure
plot(u,'.')
xlabel('Time (s)')
ylabel('Input')
title('Input Signal')
%%% Sampling Frequency
% We found the sampling frequency by...
fs = 1;
%%% Other important design choises
% We use the comments to provide clear motivations of all our design choices.
% Everything we comment directly under this header will be published as
% text.
% The text under the following line will be published as a green comment.
excitement_level = 100;
% Excitement level
%% Assignment 2: Identification
%%% Model Estimation
% We use the following identification method because...
% As you can see in our figure, we can expect that...
code = rand;  % important code

%% Assignment 3: Validation
%%% VAF
morecode= 1+1;
%%% Conlusions
% after going through the id-cycle many times we found that by doing this
% and that our results improved....
```

Using the Matlab command `publish('filename.m','pdf')` will then result in the report shown on the next page.

Filtering & Identification
Practical Assignment 2

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Jane Doe #123456 John Doe #654321

Assignment 1

Input signal

We chose the following input signal because... The following plot shows the input signal, you can see that...

```
u = ones(10,1);

figure
plot(u,'.')
xlabel('Time (s)')
ylabel('Input')
title('Input Signal')
```

Sampling Frequency

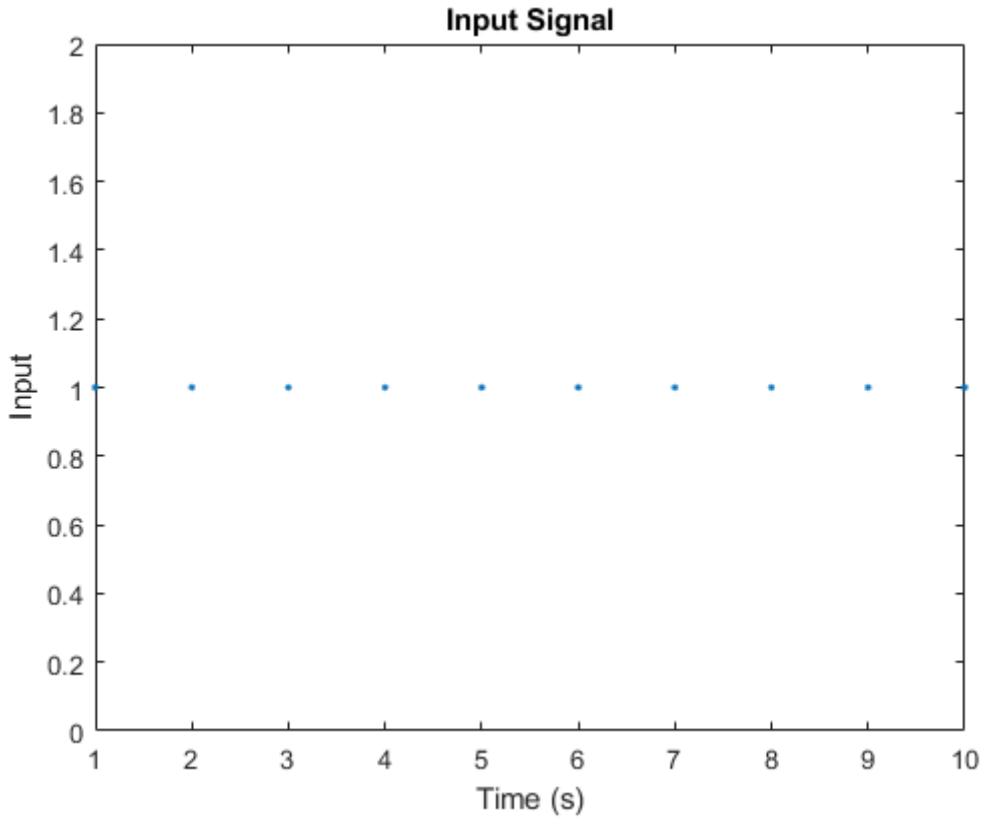
We found the sampling frequency by...

```
fs = 1;
```

Other important design choises

We use the comments to provide clear motivations of all our design choices. Everything we comment directly under this header will be published as text. The text under the following line will be published as a green comment.

```
excitement_level = 100;
% Excitement level
```



Assignment 2: Identification

Model Estimation

We use the following identification method because... As you can see in our figure, we can expect that...

```
code = rand;  % important code
```

Assignment 3: Validation

VAF

```
morecode= 1+1;
```

Conlusions

after going through the id-cycle many times we found that by doing this and that our results improved....

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