# **System Identification** – Practical Assignment 3
# Transient Analysis of Impulse Responses

## Logistics

- This practical assignment should be carried out by each student separately, if at all possible. Otherwise, if there are more students than computers, students may team up in groups of 2.
- The assignment solution consists of Matlab code. Develop this code in a single Matlab script. This code will be checked and run by the teacher during the lab class, and your attendance to the lab will only be registered if you have a working, original solution. Validated attendances for all the labs are necessary for eligibility to the exam. Moreover, at most two labs can be recovered at the end of the semester, which means accumulating three or more missing labs leads to ineligibility.
- Discussing ideas amongst the students is encouraged; however, directly sharing and borrowing pieces of code is forbidden, and any violation of this rule will lead to disqualification of the solution.

## Assignment description

Assignment 2 dealt with step response models. In this assignment we will perform transient analysis based on nonparametric, *impulse* response models – see the course material, Part II: *Step and Impulse Response Graphical Models*. Just like for the step response, we will do this for both first-order and second-order systems.

Each student is assigned an index number by the lecturer. Then, the student downloads the Matlab data files (see function `load`) that form the basis of the assignment from the course webpage:
`http://busoniu.net/teaching/sysid2019`

There are two files: the first contains several impulse inputs signals and the response of a first-order system, and the second contains similar data for a second-order system. The data is provided as an object called `data` of type `iddata` from the system identification toolbox, see `help iddata`. For convenience, a separate variable `t` holds the time vector of the experiment. Each experiment begins with 30 initial steps where the system is in its initial, steady-state condition, after which three consecutive impulse-response experiments are performed, each corresponding to 100 time steps (see the figure). Keep in mind that the initial conditions are nonzero.

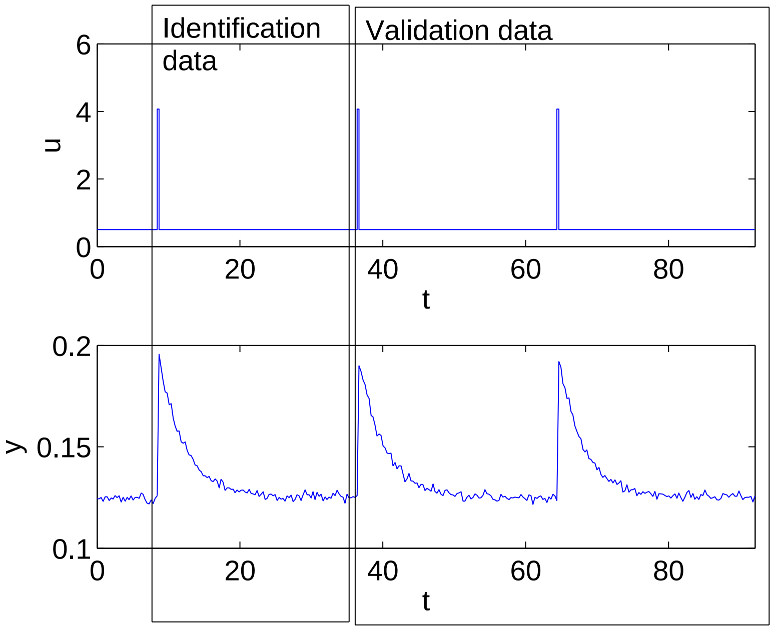
Requirements (apply this procedure first for the first-order system, and then for the second-order one):

- Develop a transfer function model of the system using the method described in Lecture 3, using the *first* impulse signal and response from the data. Include instructions that print out the transfer function, as well as relevant intermediate values (e.g. overshoot $M$, oscillation period $T_0$ in the case of second order systems) at the console when your script is run.
- Validate your model using the data for the second and third impulse responses (this is the validation data). Simulate the system from the correct non-zero initial condition; to this end, create a state space model using Matlab function `ss`. The validation should consist of: (a) a plot where the system output is compared with the model output on the same graph; (b) and the computation of the MSE. Both of these results should be automatically produced by the Matlab code you provide.

See function `lsim` to simulate the system response to the validation input, and investigate how you can provide the initial condition to this function.

For the numerical computation of the areas for the second-order impulse response, you may look at the example in the lectures. Hints: always keep in mind the difference between continuous time and the corresponding indices of discrete-time steps; and watch the signs of the integrals!

Some relevant Matlab functions: `ss, lsim, find, sum`.


Identification data
Validation data
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