System Identification – Practical Assignment 7
Pseudo-random binary sequences

Logistics

Please reread the logistics part of lab 2, the same rules will apply to this lab. The only thing that changes is the dropbox link, which for this lab is:

`https://www.dropbox.com/request/K5P5ofSbxkcuHHr9ANvc`

Assignment description

In this assignment we will study the creation and properties of pseudo-random binary sequences, PRBS. See the course material, *Input Signals*.

Each student group is assigned an index number by the lecturer. Then, the group downloads from the course webpage the `system_simulator` function, which obtains experimental data from the system given an input signal. For the purposes of this lab, since we do not have access to the real system, this simulation takes the place of the real experiment, for both identification and validation. The function is given in obfuscated, so-called p-code, so that you can treat the simulator as an unknown system, as would be the case in a real experiment. The signature of the function is `data = system_simulator(index, u)` where `index` is your index number, `u` is the input sequence (in discrete time), and `data` is the returned experimental data as a standard object of type `iddata`.

From prior knowledge, it is known that the system to be identified has order not larger than 4, and that the disturbance does not satisfy the structural assumptions of the ARX model. Nevertheless, due to its simplicity we choose to identify an ARX model, and to compensate for the disturbance structure we take large values for the orders: $na = nb = 15$. Note that in order to identify an ARX model, the input signal should satisfy a certain persistence of excitation condition, see the lecture for the details.

Requirements:

- Generate first a validation dataset with `system_simulator`, using as input e.g. the predefined input signal `u` provided in datafile `uval.mat`. You can use this dataset to validate all the models found below.
- Write a function that generates an input signal of length N using a maximum-length PRBS with a register of a given length m, and which switches between given values a and b. Parameters N, m, a, b are given as inputs to this function, and m is limited to the range $3, 4, \dots, 10$. Note that if $N > P$, the period of the PRBS, then the input signal will consist of several repetitions of the maximum-length PRBS (this should happen automatically, you do not need to do anything). Test this function for some values of N, m, a and b. Hint: You can use function `mod` to implement the modulo-2 summation.
- Generate an identification input signal of sufficient length (around 300 samples) with $m = 3$, taking values $a = 0.5$ and $b = 1$. Apply this signal to the system using `system_simulator`.
- Identify an ARX model with the identification data obtained, using either the Matlab `arx` function for simplicity, or otherwise your own code from the previous lab. Compute (on paper) the order of

persistent excitation for the input. Is it sufficient to identify properly the ARX parameters? Verify the quality of the ARX model on the validation data, and see if it supports your conclusion.

- Repeat the above but now with $m = 10$. Does this new data have a sufficient order of persistent excitation? Verify the quality of the ARX model.

Relevant functions from the System Identification toolbox: `arx`, `plot`, `compare`.