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/Lc2uUd2LXoxbDXiUt8RT`

Assignment description

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

If you did not already use the real DC motor system, familiarize yourself with this system as explained e.g. in Lab 5. The guide is at `busoniu.net/teaching/sysid2023/dcguide.pdf`.

Each student will create an input signal, obtain a data set using the DC motor, and identify the system, as detailed in the following instructions.

1. 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.
2. To keep things simple for the experiment, we will create a single, longer sequence of data containing two identification datasets, as well as a validation dataset. We will use a sampling rate of $0.01\,\mathrm{s}$ ($10\,\mathrm{ms}$). The two versions of the identification input will both be PRBS signals of length $N = 200$ with amplitude between $a = -0.7$ and $b = 0.7$, but with different number of bits m in the register: $m = 3$ for the first signal, and $m = 10$ for the second. The validation signal is a step of magnitude around 0.4 and around 70 samples in length. A short sequence of zeroes will be applied both at the beginning of the signal, and in-between each range of identification and validation inputs.
3. Apply the signal generated to the DC motor. The output is the rotational velocity. Plot the resulting input-output data. Isolate the three data ranges: identification with $m = 3$, identification with $m = 10$, and validation. **Important note**: To minimize system wear, separate the code that generates the data from the code that performs the rest of the steps below (easiest using different script sections, see *Code Sections* in the Matlab documentation), and regenerate the data only when necessary.
4. Identify two ARX model, one with each of the two identification data sets obtained, using either the Matlab `arx` function for simplicity, or otherwise your own code from the previous lab. Verify the performance of the two ARX models on the validation data. Compute the order of persistent excitation for the two identification signals, and establish a relationship between the order of PE

and the performance on the validation data. **Hints:** Even though the system is first-order, a second-order ARX model might work better. Due to serial communication issues sometimes the system exhibits time delay; if you notice a delay, try to tune nk if using ARX; or if using your code, increase the order nb accordingly so that the algorithm can figure out the delay automatically. Finally, if you use `arx`, you need to transform all the three datasets into objects of type `iddata`; and it is recommended to use `compare` to investigate performance.

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