Properties of discrete systems
Lab 7, DSP

Objective

Students should create and use discrete systems in the Simulink environment, and know how to check their linearity and time invariance properties

Theoretical aspects

The following aspects shall be explained.

1. Properties of discrete systems:
   - linearity:

   $$H\{a \cdot x_1[n] + b \cdot x_2[n]\} = a \cdot H\{x_1[n]\} + b \cdot H\{x_2[n]\}$$

   - time invariance:

   $$H\{x[n-k]\} = y[n-k], \text{ where } y[n] = H\{x[n]\}$$

Exercises

1. Create a Simulink model to implement the following system H_1:

$$y[n] = H_1\{x[n]\} = 0.8y[n-1] + 0.25x[n] + 0.1x[n-1]$$

   - the system should be implemented as a Subsystem block with one input and one output signal

2. Test linearity of this system by checking if the linearity equation holds

   - create multiple copies of the system inside the model (copy/paste)

- use two randomly generated input vectors `x` and `y` (use one of the *Random* blocks), and some two constants `a` and `b`
- check that the output of the system when the input is `a*x + b*y` is exactly equal to the weighted sum of the outputs applied separately to `x` and `y`

3. Test time-invariance in a similar way

- the system will be applied to an input vector `x`, and to `x` prepended with a variable number of zeros (i.e. time delayed)
- the outputs shall be checked if they verify the time invariance equation

4. Find an input signal $x[n]$ to show that the system $y[n] = y[n-1] + x[n]$ is unstable. Show it by simulating the model and displaying the output.

5. Repeat 1-3 for two other systems

- $y[n] = (x[n])^2 + 0.1x[n] + \sqrt{x[n]})$
- $y[n] = n \cdot x[n] + x[n-1]$

Final questions

1. TBD