Practical works – n^{o}1

Signals

• **Exercice 1** – *Deterministic signals*

1.1 Considering the Dirac function corresponding to Equation (1), write a `matlab` function `Dirac` to define a discrete signal of length `N` and containing the Dirac function at the position `n` ($\delta(k-n)$). Verify inside the function that $n \in [1, N]$ and display a warning if it is not the case.

$$\delta(k) = \begin{cases} 1 & \text{if} \quad k = 0 \\ 0 & \quad\quad \text{elsewhere} \end{cases} \tag{1}$$

1.2 Considering the step function H corresponding to Equation (2), write a `matlab` function `step` to define a discrete signal of length `N` and containing the value of the step function shifted at the position `n` ($H(k-n)$). Verify inside the function that $n \in [1, N]$ and display a warning if it is not the case.

$$H(k) = \begin{cases} 1 & \text{if} \quad k \geq 0 \\ 0 & \quad\quad \text{elsewhere} \end{cases} \tag{2}$$

1.3 Considering the ramp function $P(k)$ corresponding to Equation (3), write a `matlab` function `ramp` to define a discrete signal of length `N` and containing the values of the ramp function shifted at the position `n` with a slope `a` : $a.P(k-n)$. Verify inside the function that $n \in [1, N]$ and display a warning if it is not the case.

$$P(k) = \begin{cases} k & \text{if} \quad k \geq 0 \\ 0 & \quad\quad \text{elsewhere} \end{cases} \tag{3}$$

1.4 Considering the geometric function $G(k)$ corresponding to Equation (4), write a `matlab` function `geo` to define a discrete signal of length `N` and containing the values of the geometric function shifted at the position `n` ($G(k-n)$). Verify inside the function that $n \in [1, N]$ and display a warning if it is not the case.

$$G(k) = \begin{cases} a^k & \text{if} \quad k \geq 0 \\ 0 & \quad\quad \text{elsewhere} \end{cases} \tag{4}$$

1.5 Considering the box function $B(k)$ corresponding to Equation (5), write a `matlab` function `box` to define a discrete signal of length `N` and containing the values of the box function shifted at the position `n` with a half-width `a` : $B_a(k-n)$. Verify inside the function that $n \in [1+a, N-a]$ and display a warning if it is not the case.

$$B_a(k) = \begin{cases} 1 & \text{if} \quad -a \leq k \leq a \\ 0 & \quad\quad \text{elsewhere} \end{cases} \tag{5}$$

1.6 Write a `matlab` function `sinus` to define a discrete signal of length `N` and containing the values of $sin(2\pi f n T_s)$ where the parameters are the frequency, the number of periods (can be non-integer), the length **or** the sampling frequency. Take care of the discrete definition of this function: the repetition of the signal defined for an integer number of periods should not produce artefacts.

• **Exercice 2** – *Random signals*

2.1 Generate (`matlab` function `randn`) an observation x_n (length 1000 points or more) of the normal/gaussian random process $\mathcal{N}$. Plot the distribution of the values of this observation.

2.2 Same question with the uniform law of the random process $\mathcal{U}$ and an observation x_u.

2.3 Compute the autocorrelation of the two observations. Are these noises "white" ? Conclusion ?

2.4 Considering the observation x_n, give the model (parameters of $g(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-m)^2}{2\sigma^2}}$) of the distribution of x_n (histogram). Plot the model and compare this model to the distribution. How to normalize this distribution to obtain an estimation of the *pdf* of the normal process.

2.5 Generate three binary random signals s_1, s_2, s_3 thanks to the instruction $round(rand(1, 50))$. Generate a whole signal s containing these signals at different shifts. Compute the cross-correlation between the whole signals and s_1, s_2, s_3.

2.6 Compute the convolution product (y) of x_n with the values $h = [18\ 8\ 5\ 2\ 1]$ (`conv(x, h, 'same')`). Compute the cross-correlation of x_n with y and observe the result. Conclusion ?