Master *ViBot* Université de Bourgogne
Digital Signal Processing Le Creusot

Practical works – n^{o}2

Systems

• **Exercice 1** – *Causality*

1.1 Considering the system defined by the equation $y_k = (x_k + x_{k+1})/2$, check its causality property by examining the response to the signal $H(k-4)$ or `step(4,N)`. When plotting, include the abscissa range $[1:N]$.

1.2 Propose a modification to obtain a causal version

• **Exercice 2** – *Stability*

2.1 Program the primitive (accumulator) operator `prim(f)` applied on the signal `f` of length `N`. The value of the vector returned by `prim` at the index `k` will correspond to $\mathtt{F_k}$ with $\mathtt{k} \leq \mathtt{N}$. Note $F_k = \sum_{q=-\infty}^{k} f_k$. Discuss on the result of the primitive operator applied to the signal $H(k-4)$. Is the primitive operator stable ?

2.2 What is the impulse response of the primitive operator (in the discrete domain) ?

2.3 Test the stability of the system defined by the equation: $y_k = x_k + 2y_{k-1}$. Plot the impulse response.

2.4 Test the stability of the system defined by the equation: $y_k = x_k + y_{k-1}/3$. Plot the impulse response. Write the response y as a convolution operation (truncate the impulse response).

• **Exercice 3** – *Invariance and linearity*

3.1 Define the following signals: $\mathtt{x_a} = [\mathtt{0\,0\,0\,0\,1\,2\,3\,4\,5\,0\,0\,0\,0\,0\,0\,0\,0\,0\,0}]$; $\mathtt{x_b} = [\mathtt{0\,0\,0\,0\,0\,0\,0\,0\,0\,4\,3\,2\,1\,0\,0\,0\,0\,0\,0}]$;. Compute the responses y_a, y_b according to the equation $y = 3x_{k-1} - 2x_k + x_{k+1}$

3.2 Prove the system defined by the previous equation is linear (and invariant). Write the equation as a convolution equation.

3.3 Propose a nonlinear/noninvariant system.

• **Exercice 4** – *Convolution*

4.1 Try to write a simple version of the convolution function (do no process the limits of the signal).

4.2 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. 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 ?