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

Practical works – n$^o$4
*Sampling*

## • Exercice 1 – *Noise*

**1.1** Create a gaussian white noise signal $s_n$ of length $N = 10^6$ (`randn`) or $N = 2^{20}$. Plot this signal.

**1.2** Estimate the *pdf* (*probability density function*) by computing the histogram of the outcomes (with 50 beans for example, normalize by the length of the signal). Plot the result.

**1.3** Compute the discrete Fourier transform $\hat{s}_n$ (`fft`) of $s_n$. What is the length of $\hat{s}_n$ ? Plot [1] $|\hat{s}_n|$ with the correctly graduated frequency axis by assuming $s_n$ is a sampled signal at the frequency $f_s = 1000Hz$. Write in the comment of your program the exact frequency range.

**1.4** Create the random signal $s_b$ by sub-sampling (1/2) $s_n$. Respond to the same questions. Conclusions ?

**1.5** Create the random signal $s_c$ defined by : $s_c = \sin(s_n)$. Respond to the same questions. Conclusions ?

**1.6** Create the random signal $s_f$ defined by : $s_f = K[1\ 1]/2 * s_n$ where $K = \max s_n / \max s_f$. Respond to the same questions. Conclusions ?

**1.7** Respond to the three first questions by considering the uniform white noise $s_u$ (`rand`, remove the mean to have $\bar{s}_u = 0$).

## • Exercice 2 – *Deterministic signals*

**2.1** Define a sinusoïdal signal $s_d$ having a frequency $f_d = 1kHz$, $N_T = 10$ periods and $N = 100$ points. Plot $s_d$.

**2.2** Compute the discrete Fourier transform $\hat{s}_d$ (`fft`) of $s_d$. What is the length of $\hat{s}_d$ ? Plot $|\hat{s}_d|$ with the correctly graduated frequency axis by deducing the sampling frequency $f_s$. Comment.

**2.3** Change $f_d$, $N_T$ (can be non-integer) and $N$. Comment your observations.

**2.4** Define a square signal $s_q$ having a regular pattern period (between $-1$ and 1) for $N_T$ integer (do not use `square`). Plot $s_q$.

**2.5** Compute the discrete Fourier transform $\hat{s}_d$ (`fft`) of $s_q$. What is the length of $\hat{s}_q$ ? Plot $|\hat{s}_q|$ with the correctly graduated frequency axis by deducing the sampling frequency $f_s$. Compare to the Fourier series of the continuous square signal. Conclusions ?

## • Exercice 3 – *Sound !*

**3.1** "Play" with this code.

```
fSampRecord = 10000; % Hz (RTC: 3400Hz, GSM:4kHz)
nBitsRecord = 16;
nChannelsRecord = 1;
deviceRecord = -1; %default
fSampPlay = 20000; % Hz
r = audiorecorder(fSampRecord, nBitsRecord, nChannelsRecord, deviceRecord);
record(r);
ch=sprintf(' <<< recording during 3s at frequency %6.0f Hz >>>', fSampRecord); disp(ch)
pause(3); %3 secondes
stop(r); % stop recording
disp('-> playback !');
play(r); % sampling rate cannot be changed in the record
pause(4);
p = audioplayer(r); % create a player from the record
set(p, 'SampleRate', fSampPlay); % new sampling rate
ch=sprintf('-> playing at frequency %6.0f Hz', fSampPlay); disp(ch);
```

[1] Use `fftshift` to obtain a centered plot