I. Frequency analysis

- Fourier transform-

The power spectral density (PSD) or "spectrum of a signal", reveals the existence or absence of the frequency of a signal, which is very important in the processing of physiological signals in order to make a reliable discrimination between normal and pathological cases.

There are several spectral estimation methods, each with its own advantages and disadvantages. These methods can be grouped into four categories:

- Fourier transform (or the spectrum)

- The periodogram

- Welch's methods (or the averaged periodogram)

- Correlogram.

In this practical work (pw) we will analyse EEG signals using the above methods:

Note: These analysis methods only give an estimate of the spectrum and are not the true spectrum.

1. Fourier transform (signal spectrum)

The Fourier transform is an extension « for non-periodic functions » of the Fourier series decomposition appieded only on periodic functions.

The Fourier transform is associated with an integrable function defined on IR and with real or complex values. It is defined by equation (1.1) :

$$X(f) = (\sum_{n=1}^{N} x(n)e^{-j2\pi fn}) \qquad (1.1)$$

Where :

X(f): is the spectrum of the signal

x(n) :is the time signal

N: is the number of samples

f: is the frequency.

2. *Periodogram :*

The periodogram is used to identify the dominant periods (or frequencies) in a time series. It can be a useful tool for identifying the dominant frequency in the series. It is given by the equation (eq 1.2).

$$X(f) = (\sum_{n=1}^{N} x(n)e^{-j2\pi fn})^2 \qquad (1.2).$$

The periodogram has one advantage (good selectivity of the spectrum peak) and two disadvantages (it represents a noisy spectrum, and the "peak shift").

3. Welch (Averaged periodogram) :

Welch's method (also known as the averaged periodogram method) is used to estimate power spectra. It is performed by :

- Dividing the time signal into successive segments using rectangular windows.
- Then determining the periodogram for each segment.
- Finally, averaging.

Welch's method has two advantages (a noise-free spectrum with no shift) and one disadvantage (it is less selective for the broader peaks in the spectrum).

4. Correlogram :

It is defined as the Fourier transform of the correlation function.

MATLAB script :

The following MATLAB code is used to estimate the PSD using the perdiodogram of three EEG signals representing a normal case, a pre-ictal case and an epileptic case.

```
clear all;
close all;
clc;
s1=load('O001.txt');
s2=load('N001.txt');
s3=load('S001.txt');
fs=173.61 ;
t=[1:length(s2)];
xx=abs(fft(s1));
freq=[1:length(xx)];
plot((freq/fs)*(2*pi), xx(1:length(xx)))'
title ('Spectral power density')
```

MATLAB CODE: PERIODOGRAM

```
clear all;
close all;
```

```
clc;
s1=load('O001.txt');
% s2=load('N001.txt');
% s3=load('S001.txt');
fs=173.61 ;
 t=[1:length(s2)];
[ps,f]=periodogram(s1);%,hamming(1024),[],128,fs);
freq=[1:length(ps)];
 plot((f/pi)*fs, ps)
 title ('Spectral power density')
```

MATLAB CODE : WELCH method

```
clear all;
close all;
clc;
s1=load('O001.txt');
s2=load('N001.txt');
s3=load('S001.txt');
fs=173.61 ;
 t=[1:length(s2)];
[ps,f]=pwelch(s1,hamming(512),[],128,fs);
freq=[1:length(ps)];
 plot(freq, ps)
 title ('Spectral power density')
```

MATLAB CODE : CORRELOGRAM

```
clear all;
close all;
clc;
s1=load('O001.txt');
s2=load('N001.txt');
s3=load('S001.txt');
fs=173.61 ;
 t=[1:length(s2)];
ps=abs(fft(xcorr(s2)));
freq=[1:length(ps)/2];
 plot((freq/fs)*(2*pi), ps(1:length(ps)/2))
 title ('Spectral power density')
```