Cours de traitement des signaux biomédicaux
2ème séance Matlab

Useful commands

subplot	to pile up graphs.
freqz	filter frequency response.
cheb1ord	design of a Chebyshev filter
cheby1	synthesis of a Chebyshev filter
pwelch	non-parametric spectral power density estimation.
resample	signal resampling.
xcov	cross-covariance.

Additional routines

test_white	whiteness test
your_rand	‘’manual’’ random signal generation

Some remarks

- Some of the signals have a non-zero mean. To perform spectral density (psd) estimation with pwelch, you must first subtract this mean in order not to get a huge peak at *f* = 0.
- If pwelch is called without anz output variable, Matlab plots directly the psd estimate in dB. To get a linear graph, with fe the sampling freq uency :
  >> [Px,f] =pwelch(x,…..) ;
  >> plot(f,Px)
  And to plot the psd up to a maximum frequency fmax:
  >> Ind = find(f<=fmax) ;
  >> plot(f(Ind),Px(Ind));
- If pwelch is applied to a vector (signal) x of length N (not too small) a good choice is often :
  >> [Px,f] = pwelch(x-mean(x),N/4,[ ],[ ],fe);
  If N can be divided by par p. Typically, p=2 or p=4.
- To compute the signal power in the frequency band 0.04-0.15 Hz a possible command is (why ?):
  >> Puis = (fe/length(Px))*sum(Px(find((f>=0.04)&(f<0.15))))

Experiment 1 : there is indeed an interference
The signal stored in **ecg.dat** corresponds to several seconds of an ECG sampled at500 Hz. Visualize its power spectral density estimate with pwelch (no output) to verify the presence of the interference at 50 Hz.

Experiment 2 : cardiovascular signals
Note : the signals are stored in the files **heart_1.dat** et **heart_2.dat**, described in **readme_heart.txt**.
2.1 On the cardiovascular signals in **heart_1** et **heart_2** estimate the psd (modified estimator, remove the average value, sub-interval length 500) and plot one under the other the 3 estimates (limit the maximum frequency to 0.4 Hz). What information can be retrieved (baroreflex peak in the RR-interval psd, peak in the RR-interval and arterial pressure psd at the respiration frequency)? What are the effects of alcohol ?

2.2 Estimate the RR-interval signal power in the LF band (0.04-0.15 Hz) for the two conditions. Conclusion ?
2.3 Resample the RR interval signal of **Heart_1** at 2 Hz using `resample`. Check by plotting the amplitude responses on the same graph that the commands :

```
>> [N,wn]=cheb1ord(0.04,0.05,0.5,20);
>> [b1,a1] = cheby1(N,0.5,wn);
>> [N,wn]=cheb1ord([0.05 0.14],[0.03 0.16],0.5,20);
>> [b2,a2] = cheby1(N,0.5,wn);
>> [N,wn]=cheb1ord([0.16 0.39],[0.14 0.41],0.5,20);
>> [b3,a3] = cheby1(N,0.5,wn);
```

Generate three filters extracting the signal components in the three physiological bands. Plot on stacked graphs the original signal and the three filter outputs so as to identify to which time features the components correspond (in particular the baro-reflex activity). The command :

```
>> set(gca,'Ylim',[a b])
```

Allows you to scale the graph vertical range between `a` and `b` to have the same scale on all graphs.
2.3 Apply the same filters to the arterial pressure (resampled at 2 Hz), and estimate the cross-covariance between the two LF components. **Warning: the Matlab convention for lags is just the opposite of the one in the course.** What causes what? Estimate the cross-covariance between the HF component of the RR intervals and the respiration (sampled at 2 Hz). What can you conclude? Verify that by plotting the two signals (normalized by their maximum value) on the same graph.

Experiment 3 : are you a good random generator ?

Use `your_rand` to try to generate yourself a Bernouilli-type (values +1 or –1) white noise with a length of at least 50 samples. Apply the whiteness test to the result. Are you a good random generator?