HW 1

Task 1

A multi-channel EEG dataset are provided in the file eeg1-x.dat. (x: f3, f4,c3, c4 p3, p4, o1, o2. The sampling rate is 100 Hz.

- Show the ACF of the 4.2-4.96 s segments of f3 and o1, respectively channels (eeg1-f3.dat, eeg1-o1.dat,)
- Show Crosscorrelation of o1 and o2 during 4.72~5.71 secs (eeg1)
- Show Crosscorrelation of o1 and f3 during 4.72~5.71 secs (eeg1)

Task 2

A noisy ECG signal is provided in the file ecg.hfn.dat. (See also the file ecg.hfn.m). The sampling rate of this signal is 1000 Hz.

- Develop a program for beat detection. Select a QRS complex from the signal for use as the template and use a suitable threshold on the cross-correlation in Equation 3.18 for beat detection. Mark the detect beats.
- Calculate and label the BPM (beat per minute) and the R-R interval of the ECG signal.

Due date: PPT report 9:10 a.m. 10/4 2023

(From Ch3, Biomedical Signal Analysis, Rangaraj M. Rangayyan, Wiley, ISBN: 0-471-20811-62.)

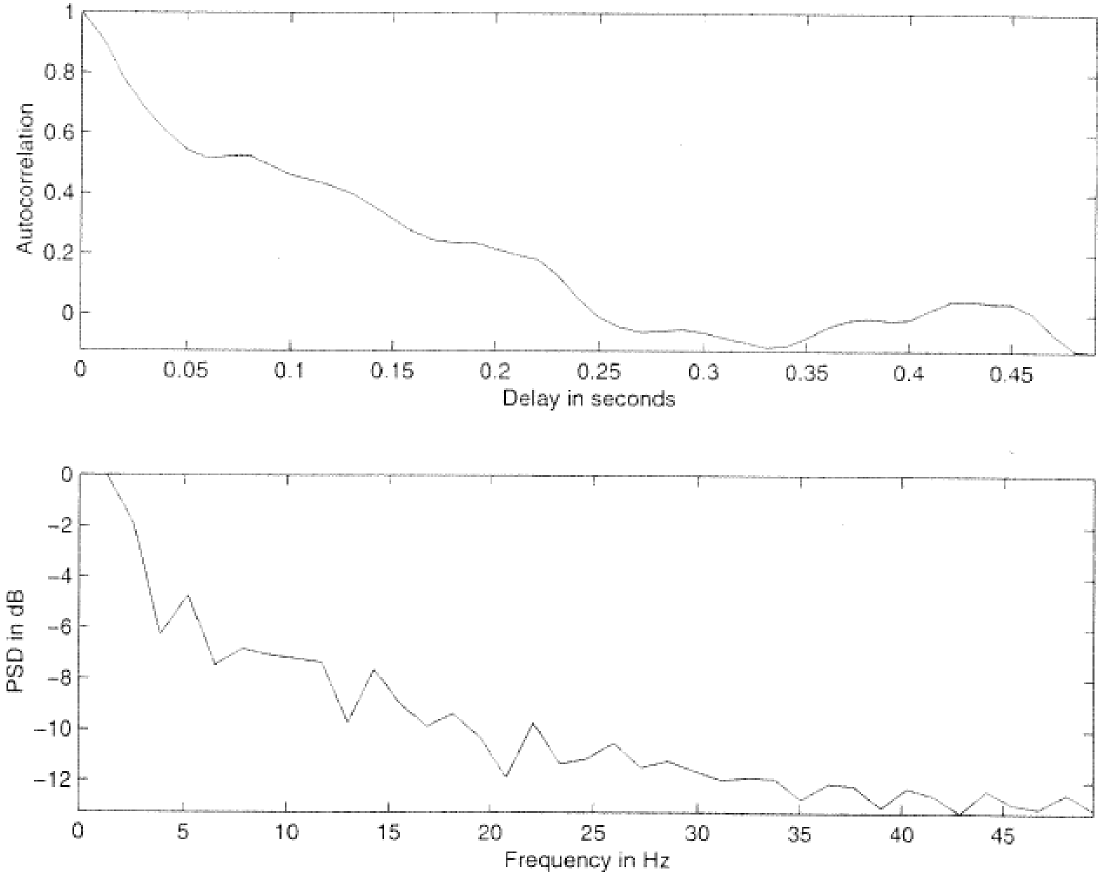
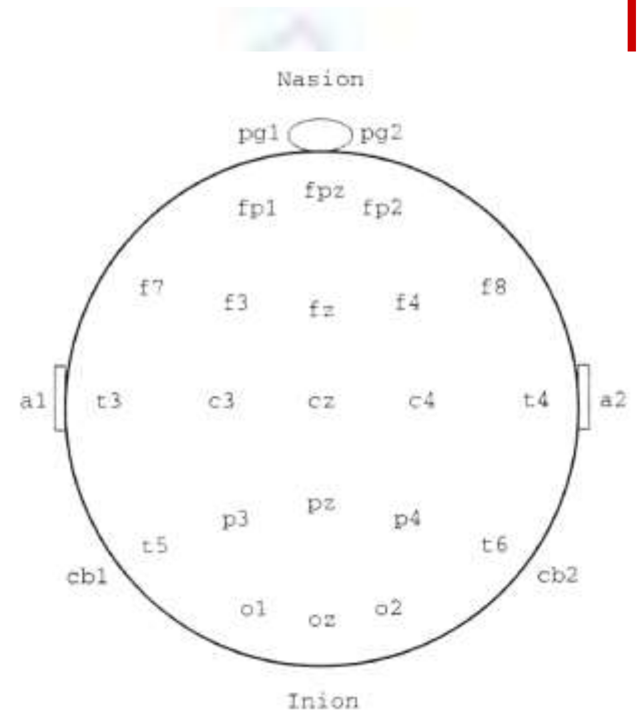


Figure 4.9 Upper trace: ACF of the 4.2 – 4.96 s portion of the f3 channel of the EEG signal shown in Figure 1.22. Lower trace: The PSD of the signal segment in dB.



ecg.hfn.dat

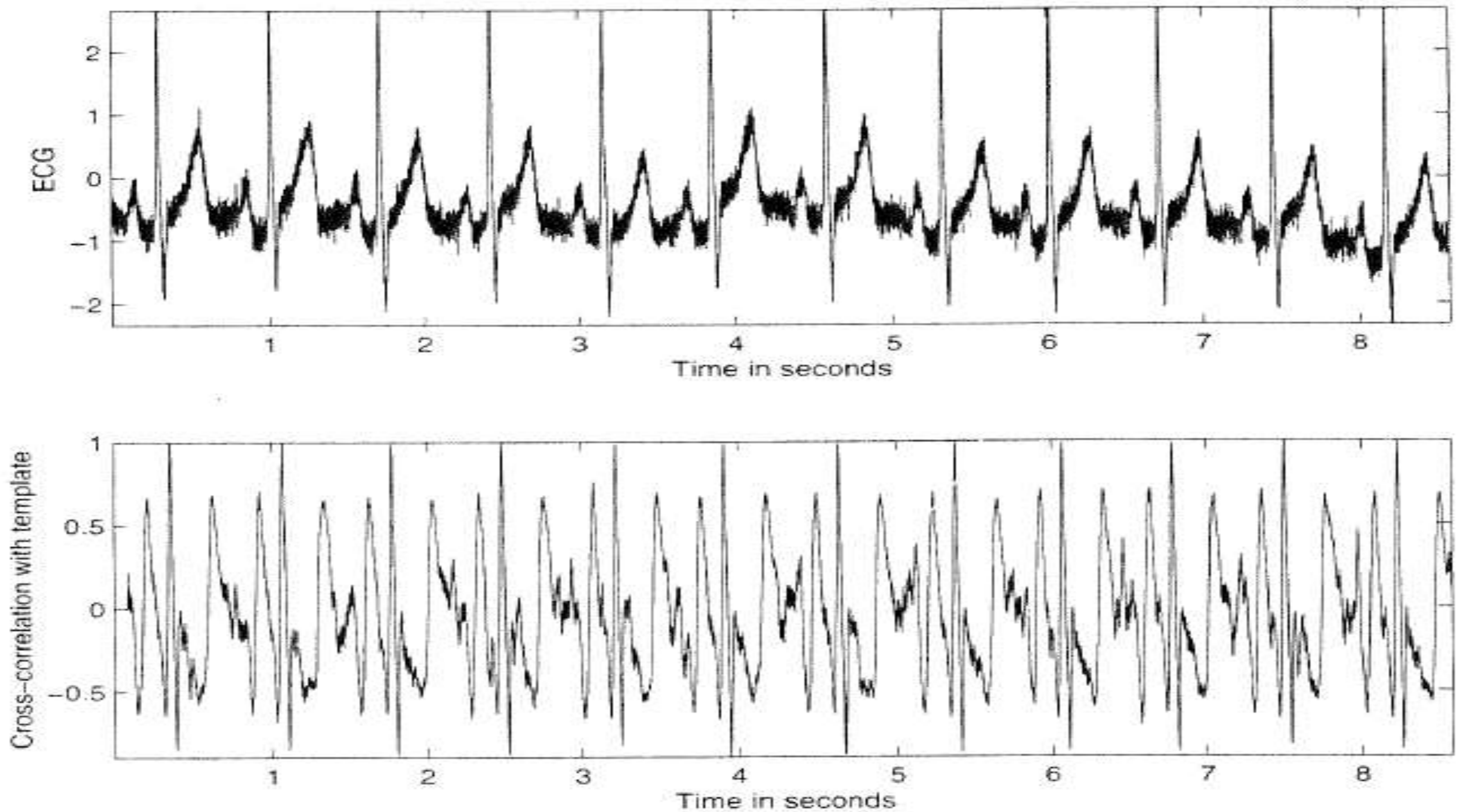


Figure 3.13 An ECG signal with noise (upper trace) and the result of cross-correlation (lower trace) with the QRS template selected from the first cycle. The cross-correlation coefficient is normalized to the range $(-1, 1)$.

(From PP. 97, Ch3, Biomedical Signal Analysis, Rangaraj M. Rangayyan, Wiley, ISBN: 0-471-20811-62.)

Illustration of application: The upper trace in Figure 3.13 illustrates a noisy ECG signal over several beats. In order to obtain trigger points, a sample QRS complex of 86 ms duration (86 samples at a sampling rate of $1,000\ Hz$) was extracted from the the first beat in the signal and used as a template. Template matching was performed using a normalized correlation coefficient defined as [79]

$$\gamma_{xy}(k) = \frac{\sum_{n=0}^{N-1}[x(n) - \bar{x}][y(n-k) - \bar{y}]}{\sqrt{\sum_{n=0}^{N-1}[x(n) - \bar{x}]^2 \sum_{n=0}^{N-1}[y(n-k) - \bar{y}]^2}}\,, \qquad (3.18)$$

where x is the template, y is the ECG signal, $\bar{x}$ and $\bar{y}$ are the averages of the corresponding signals over the N samples considered, and k is the time index of the signal y at which the template is placed. (Jenkins et al. [67] used a measure similar to $\gamma_{xy}(k)$ but without subtraction of the mean and without the shift parameter k to match segmented ECG cycles with a template.) The lower trace in Figure 3.13 shows $\gamma_{xy}(k)$, where it is seen that the cross-correlation result peaks to values near unity at the locations of the QRS complexes in the signal. Averaging inherent in the cross-correlation formula (over N samples) has reduced the effect of noise on template matching.

Example
BPM (beat per minute) and the R-R interval of the ECG