HW 1

- Data file will be upload to the Moodle

Problem 1

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 $1,000\ Hz$.

Develop a MATLAB program to perform synchronized averaging as described in Section 3.3.1. Select a QRS complex from the signal for use as the template and use a suitable threshold on the cross-correlation function in Equation 3.18 for beat detection. Plot the resulting averaged QRS complex. Ensure that the averaged result covers one full cardiac cycle. Plot a sample ECG cycle from the noisy signal for comparison.

Observe the results when the threshold on the cross-correlation function is low or high.

Problem 2

Average the ECG signal by 2 and 4 points, plot the waveforms and discuss the results.

Due date: PPT report 10/17 2019

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

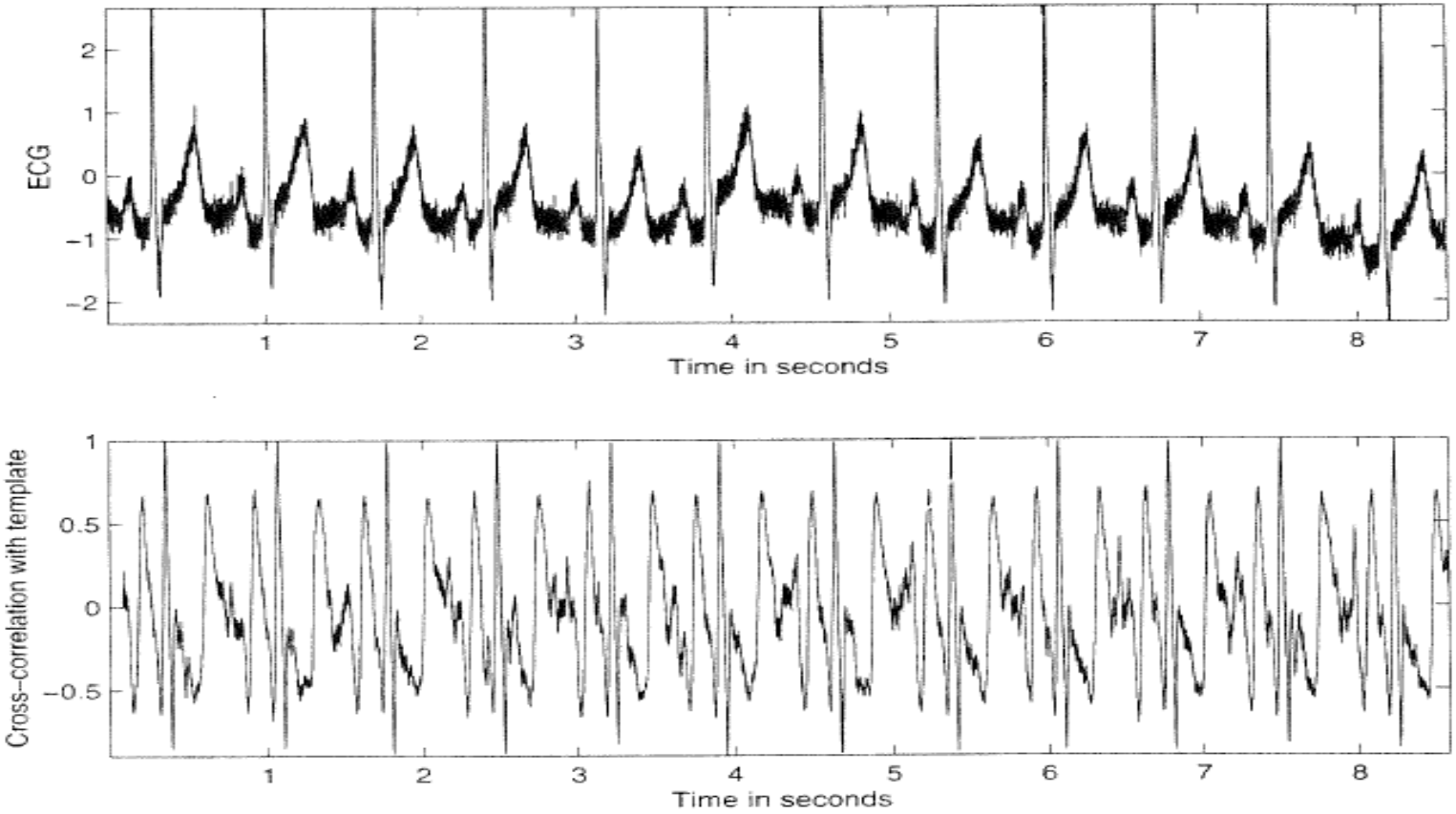

Figure 3.13 An ECG signal with noise (upper trace) and the result of cross-correlation (lower trace) with the QRS template selected from the first cycle. The cross-correlation coefficient is normalized to the range $(-1, 1)$.

(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.

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