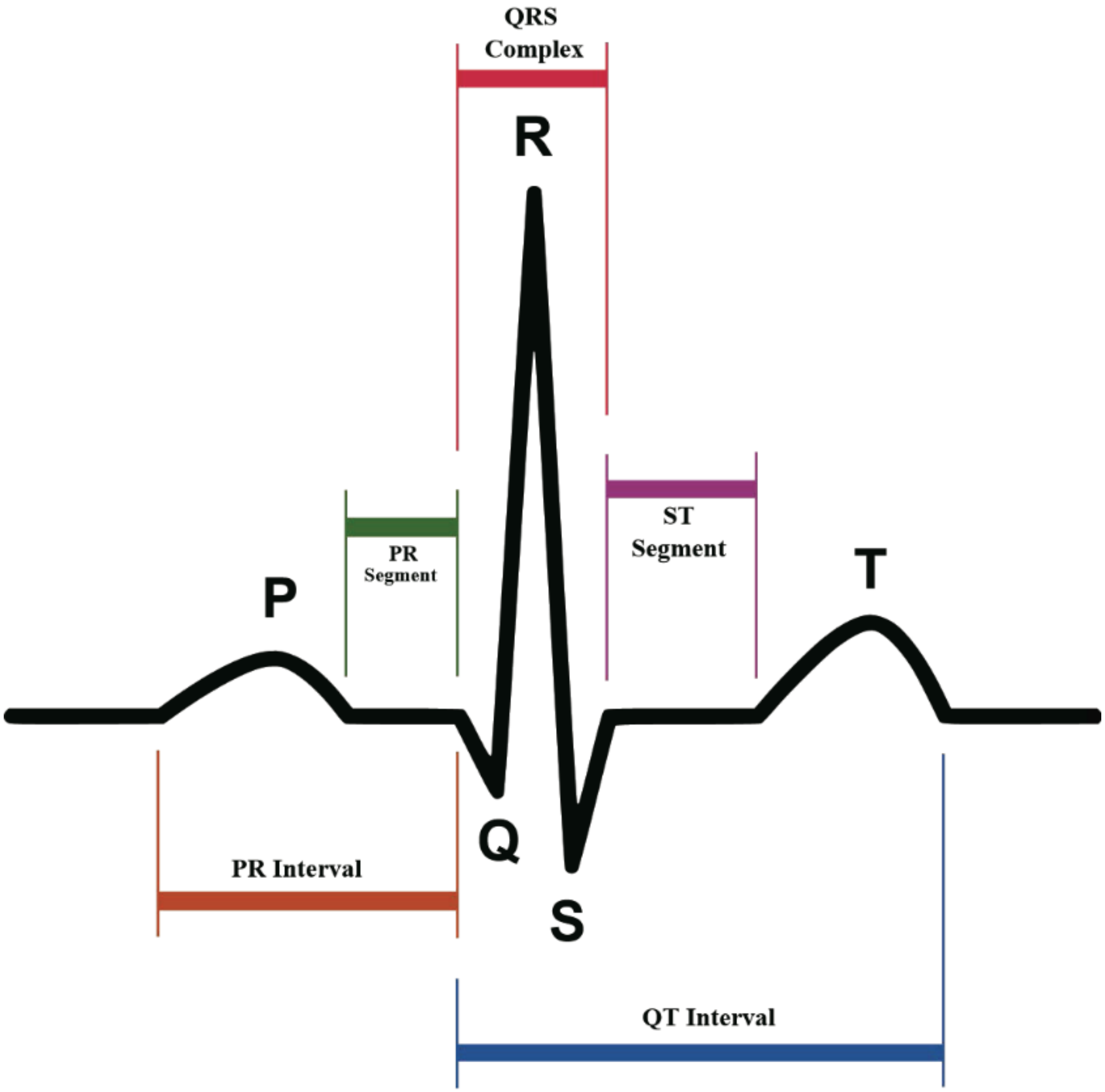
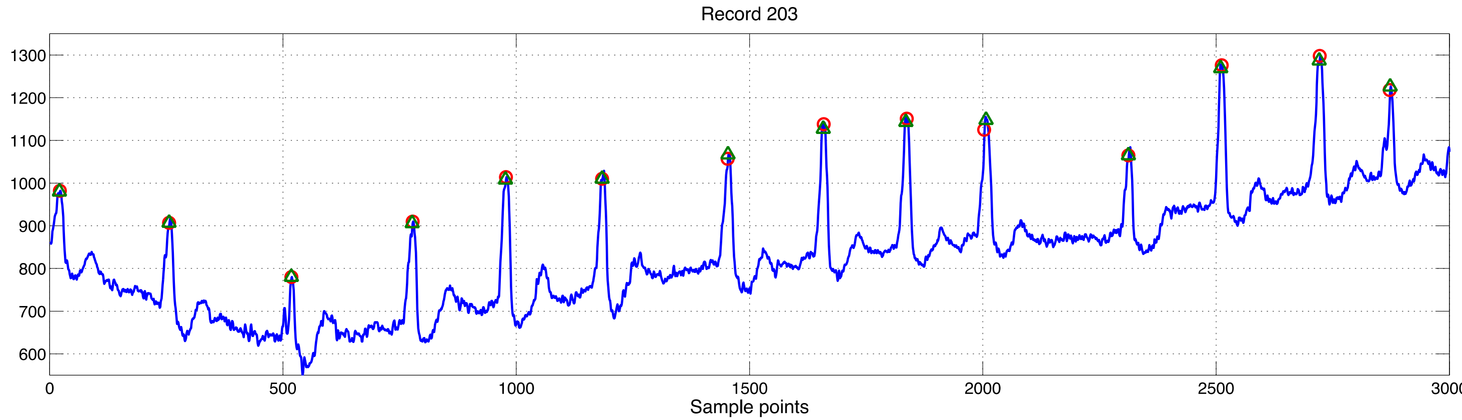
數位訊號處理實驗
Digital Signal Processing Laboratory
Lab 3
Pre-Processing of ECG Signals

ECG Signal and Interferences (1/2)

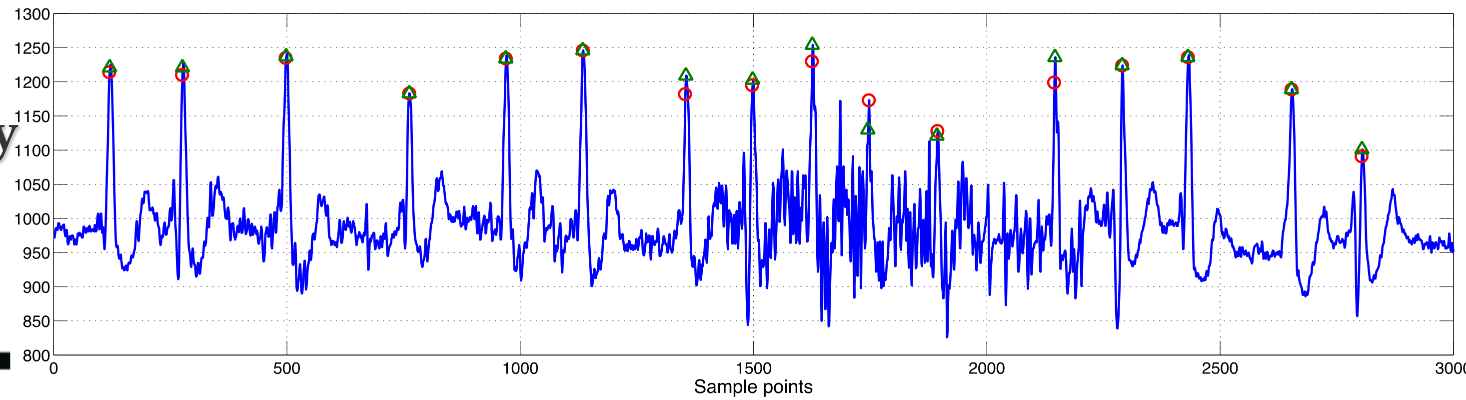


ECG Signal and Interferences (2/2)

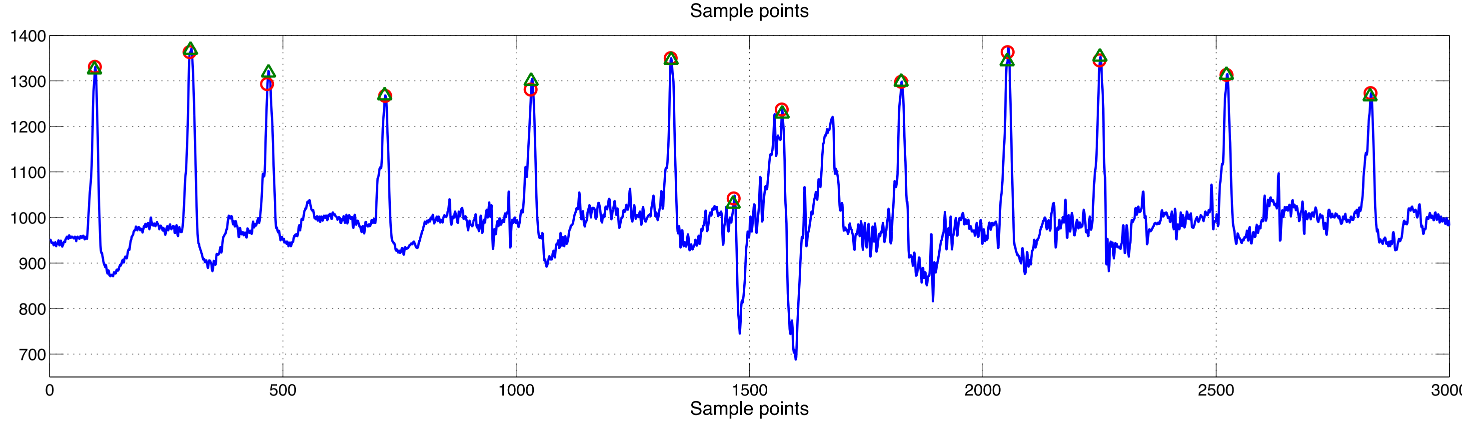
Baseline Noise



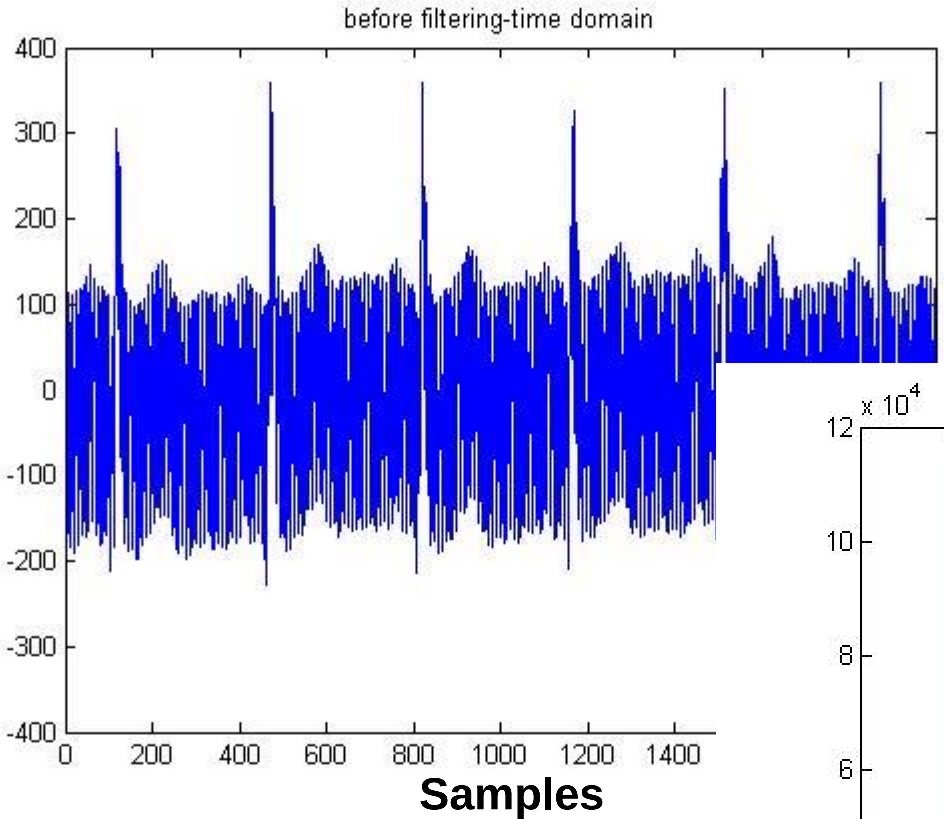
Electromyography (EMG) Noise

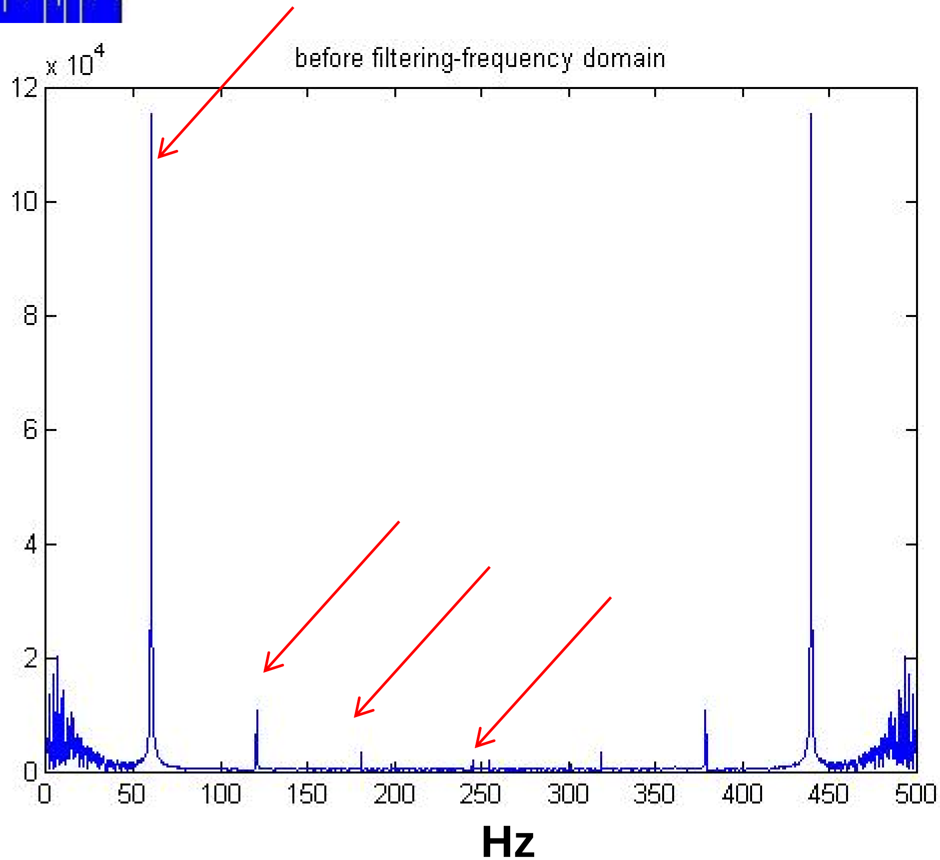


Motion Artifact



60-Hz Power-Line Interference





ECG Noise Reduction

Noise types:

Baseline wander (BW) (below 1Hz)

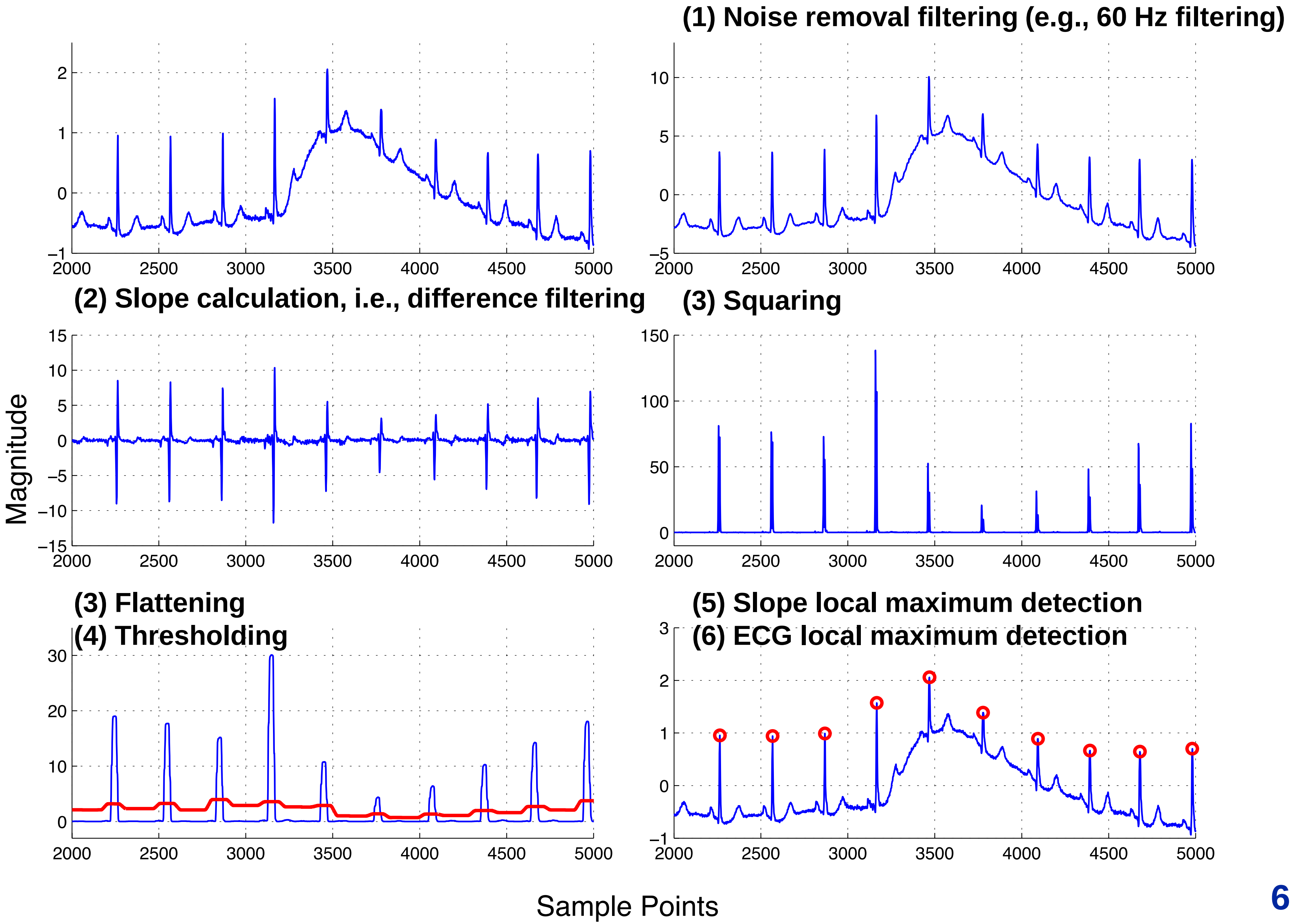
50 or 60 Hz power-line interference (PLI)

Electromyogram (EMG)

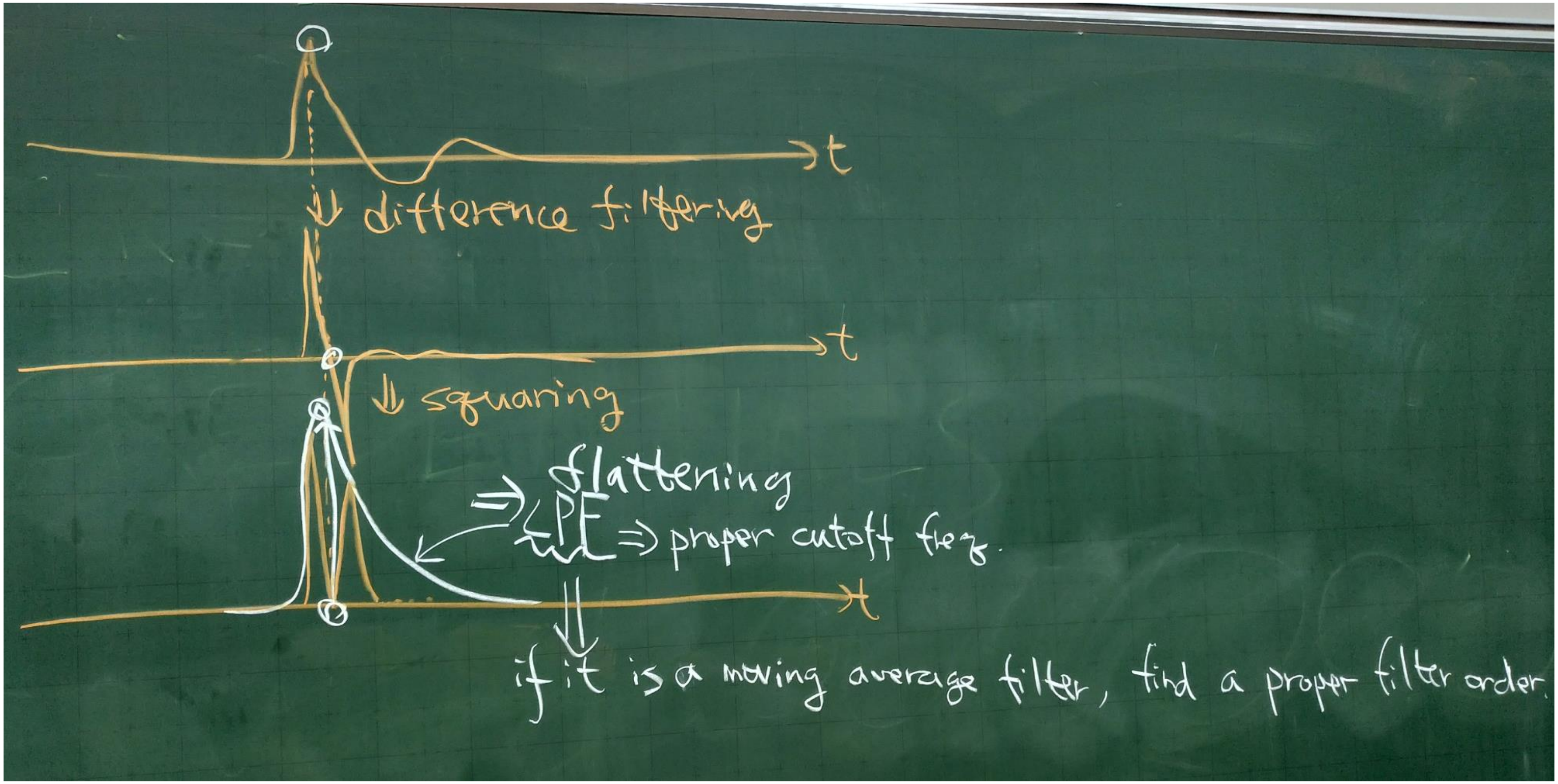
Motion artifact (MA)

Method	Noise Type
Adaptive Filter	BW, PLI, MA
Wavelet Transform	BW, EMG, MA
Empirical Mode Decomposition	BW, EMG, MA
Independent Component Analysis	MA
Moving Average	BW, (PLI), MA

Pre-Processing of ECG Signals (1/4)



Pre-Processing of ECG Signals (2/4): Why Squaring and Flattening



Pre-Processing of ECG Signals (3/4)

(1) 60 Hz filtering:

$$x[i] = \frac{1}{M} \sum_{K=i-M/2}^{i+M/2-1} r[k].$$

(Low pass filtering: moving average filtering, FIR, How about IIR?)

(2) Slope calculation:

http://oregonstate.edu/instruct/ch490/lessons/lesson11.htm

$$X_d[i] = 2x[i] + x[i-n] - x[i-2n] - 2x[i-3n].$$

(High pass filtering: difference filtering, FIR, How about IIR?)

(3) Squaring and flattening:

$$\hat{X}_d[i] = X_d^2[i], \qquad \hat{X}_{df}[i] = \frac{1}{N} \sum_{k=i-N/2}^{i+N/2-1} \hat{X}_d[k].$$

(4) Adaptive threshold calculation:

(Low pass filtering: moving average filtering, FIR, How about IIR?)

$$TH = \frac{1}{S/2} \sum_{n-S/4}^{n+S/4} \hat{X}_{df}[i].$$

Pre-Processing of ECG Signals (4/4)

(4) Hard threshold:

$$\hat{X}_{dfT}[i] = \hat{X}_{df}[i] - TH, \qquad \begin{cases} \hat{X}_{dfT}[i], & \hat{X}_{df}[i] - TH > 0 \\ 0 & \hat{X}_{df}[i] - TH < 0 \end{cases}$$

(5) Slope local maximum detection

Find the time index *i* of the local maximum of the slope.

(5) ECG local maximum detection:

Use the sample index *i* to find the local maximum of original ECG signal by applying a short searching range.

Searching region is set to be 0.1 second since normal QRS complex (5-40Hz) is about 80~100 ms duration.

Task 3 (in the Handout) Today

Use 8 bits instead of 10 bits for the digitization of ECG signals. Design an algorithm and implement in Arduino to maintain the maximum dynamic range of the input ECG signal with 8-bit sampling.

> From 10 bit to 8 bit sampling while maintaining the maximum dynamic range of the ECG signals can (1) reduce the data rate and (2) for example, utilize the full swing (full range) of a following DAC (8 bit).

Task 3 (in the Handout) Today