Convolution and Correlation

Expt.2: To find Convolution and correlation of signals

- Objective:

(i) To perform convolution of two signals

(a) with built-in function

(b) without built-in function

(ii) To perform correlation of two signals

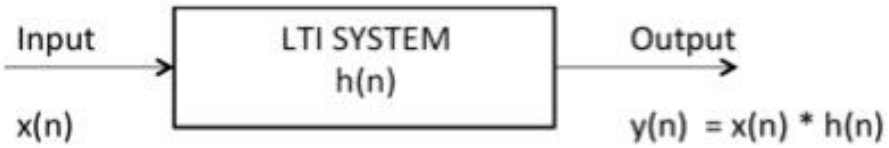
(a) with built-in function

(b) without built-in function

(iii) Find the correlation of ECG signal and its delayed version [choose the delay]

Convolution

- Two types:
  - Continuous convolution
  - Discrete convolution



$$y(n) = x(n) * h(n)$$

$$= \Sigma_{k=-\infty}^{\infty} x(k)h(n-k)$$

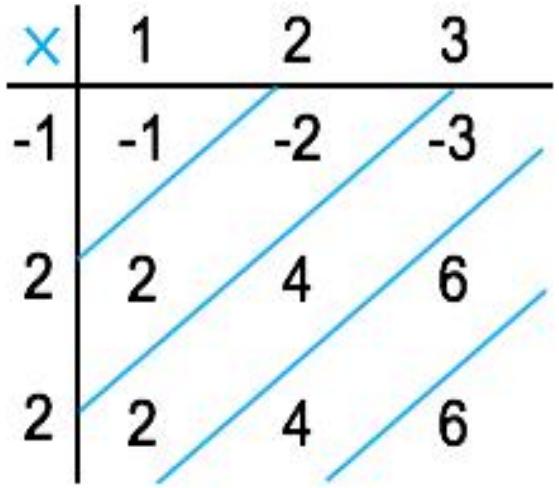
Methods to perform

Two ways:

- Linear convolution
- Circular convolution

Ex:

$x[n] = \{1, 2, 3\}$ & $h[n] = \{-1, 2, 2\}$



- Y(n)= [-1, 0, 3, 10, 6]

Manual calculation

X[n] = {1 2 3} and h[n] = {-1 2 2}

Convolution:

Y[n] = x[n]*h[n]

X	1	2	3
-1	-1	-2	-3
2	2	4	6
2	2	4	6

Therefore y[n] = {-1, 0, 3, 10, 6}

Correlation:

Y[n] = x[n]*h[-n]

X	1	2	3
2	2	4	6
2	2	4	6
-1	-1	-2	-3

Therefore y[n] = {2, 6, 9, 4, -3}

Correlation

- Two types
  - Auto correlation
  - Cross correlation

Auto correlation function is a measure of similarity between a signal & its time delayed version.

The cross correlation of x(n) and y(n) is a sequence $\gamma_{xy}(l)$, which is defined as

$$\gamma_{xy}(l) = \sum_{n=-\infty}^{\infty} x[k]y[n-l] \qquad l = 0, \pm 1, \pm 2 \ldots \ldots$$

which can be alternately written as

$$\gamma_{xy}(l) = \sum_{n=-\infty}^{\infty} x[n+l]y[n] \qquad l = 0, \pm 1, \pm 2 \ldots \ldots$$

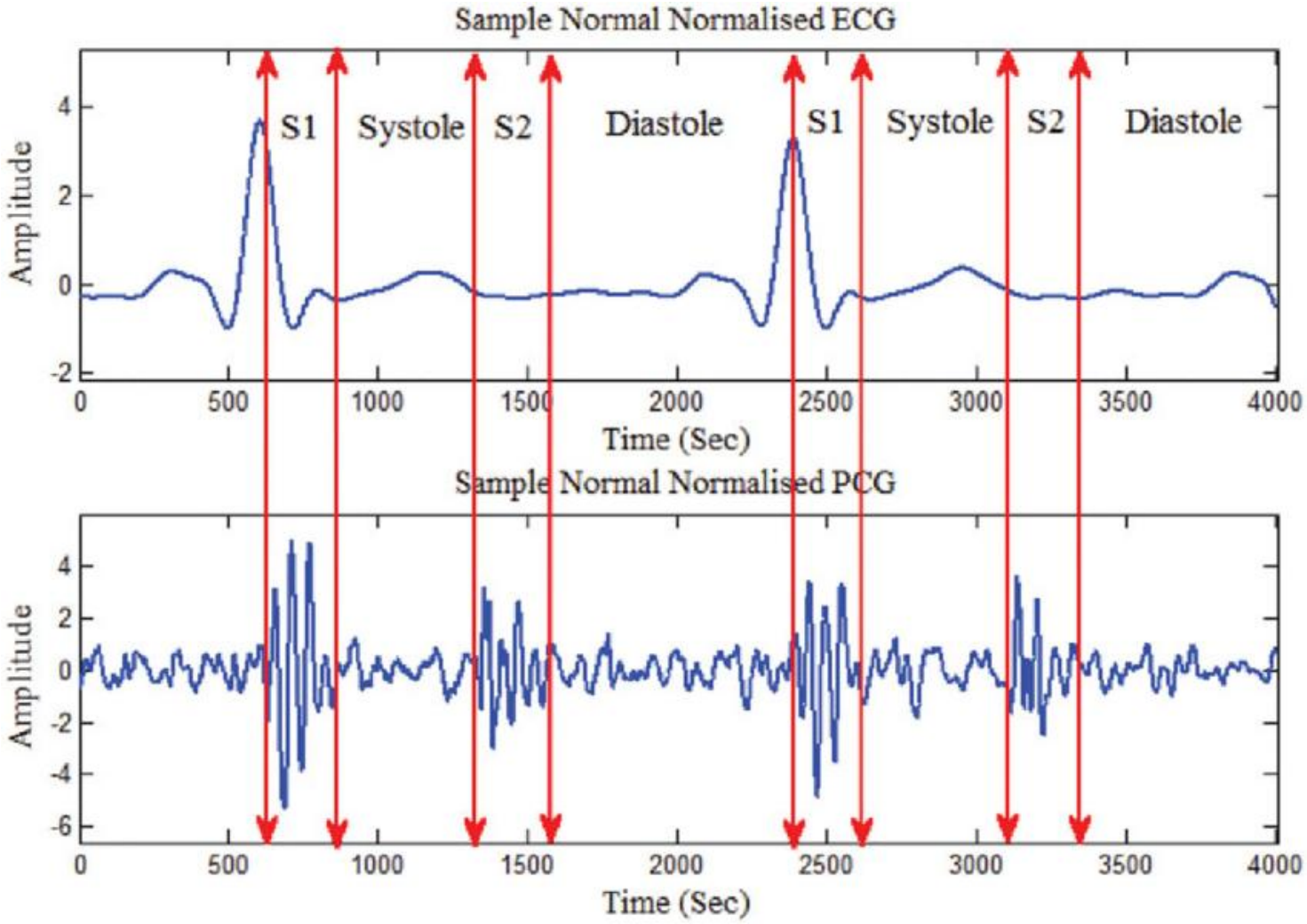
Built-in function

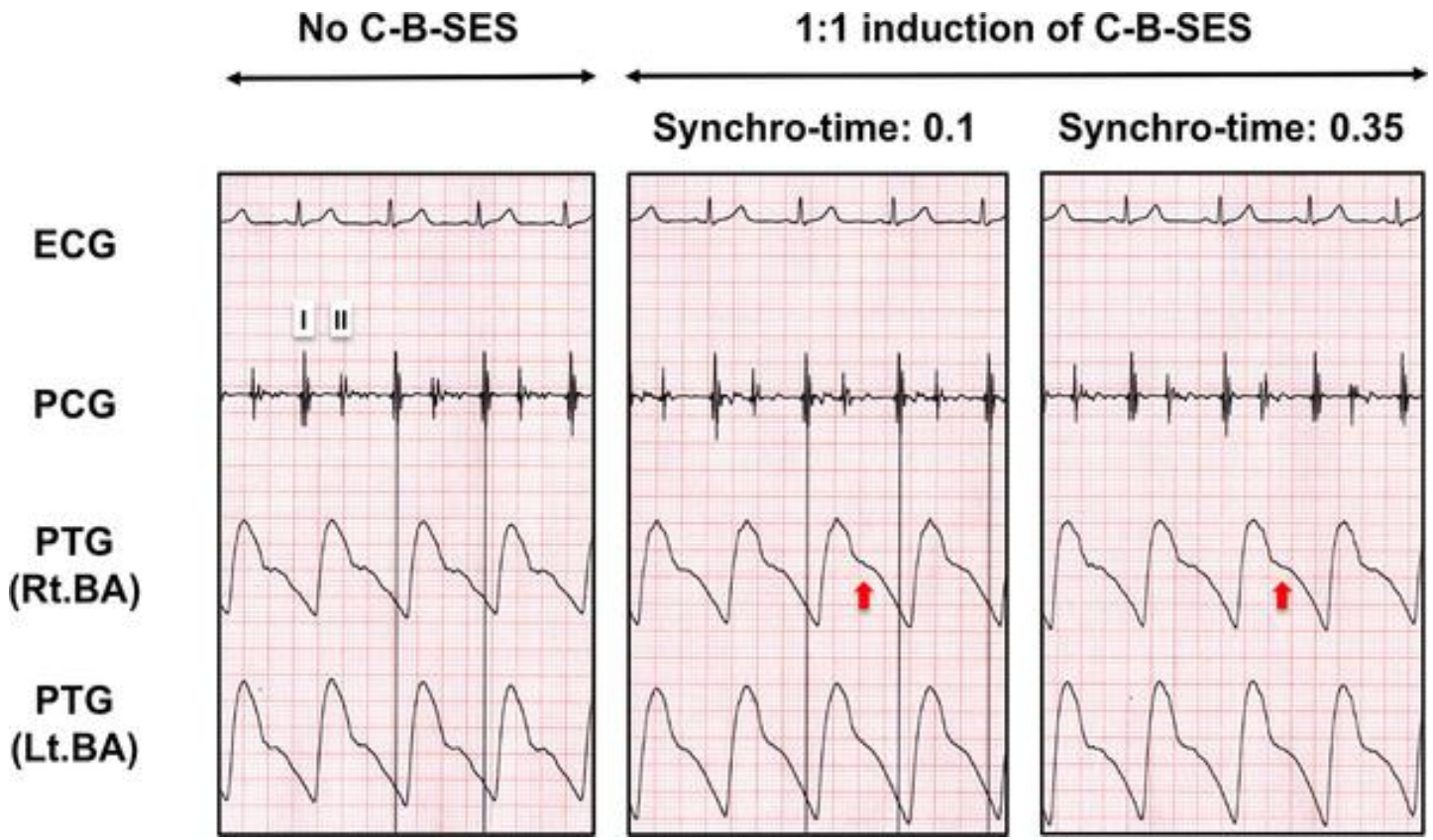
- conv (x1, x2)
- xcorr (x1, x2)
- fliplr(y)

Cross correlation

$$\gamma_{xy}(l) = x(1) * y(-1)$$

Real-time example for cross correlation




No C-B-SES
1:1 induction of C-B-SES
Synchro-time: 0.1
Synchro-time: 0.35
ECG
I II
PCG
PTG
(Rt.BA)
PTG
(Lt.BA)