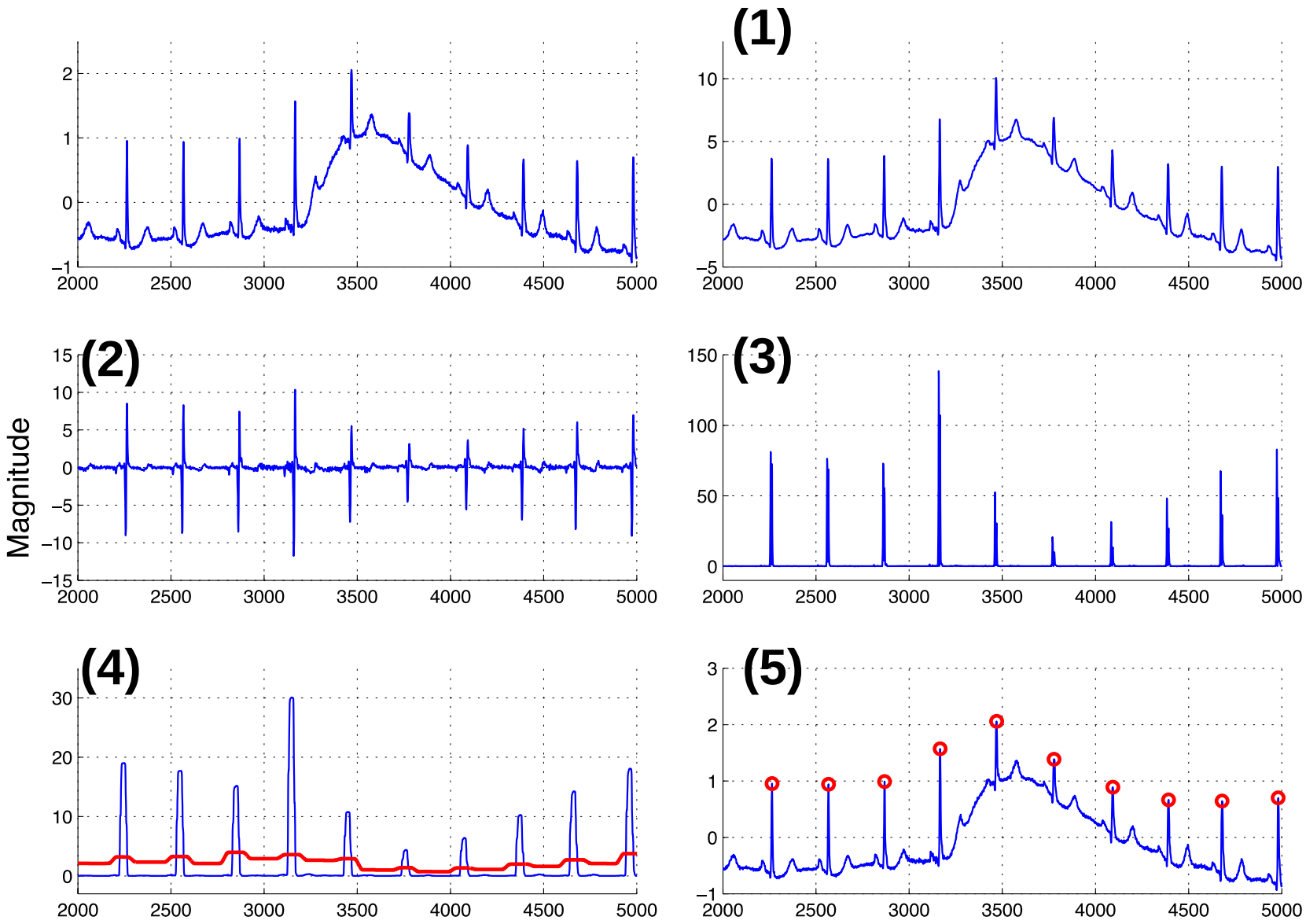
數位訊號處理實驗
Digital Signal Processing Laboratory
Lab 4
Heart Rate Estimation

Task 1

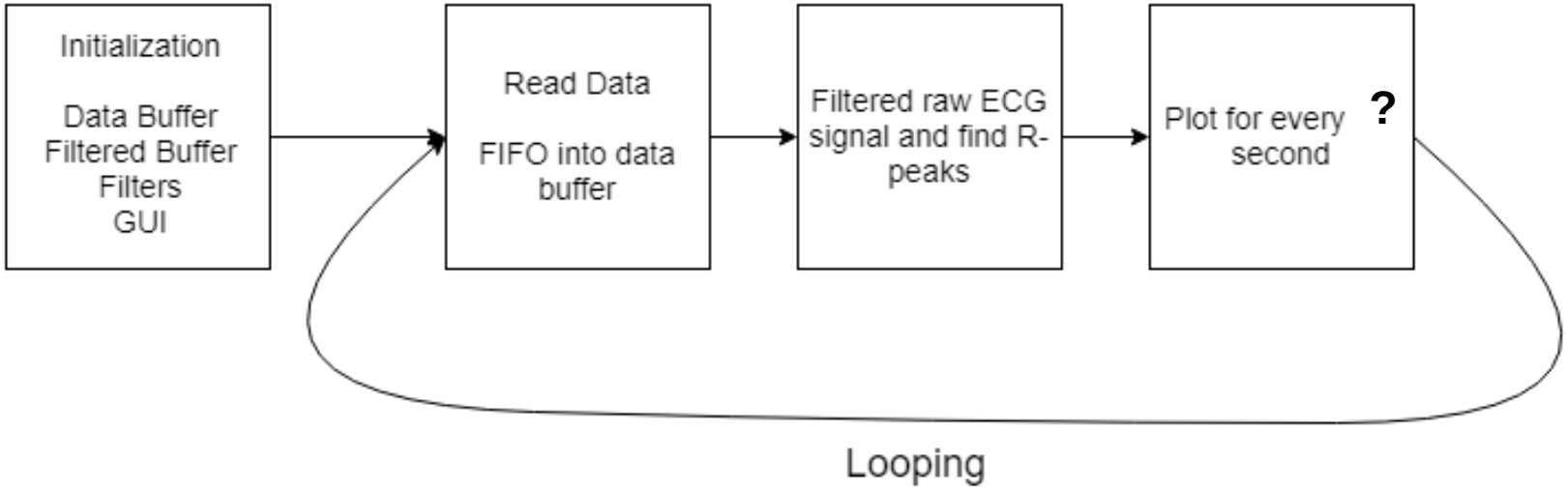
- Detect the R wave from your recorded ECG signals.

Pre-Processing of ECG Signals to Locate R Peaks (3/3)



Task 3

- Implement the pre-processing of the ECG signals(Lab 3) and R-peak detection in real time and display the processed ECG signals (i.e., noise-reduced ECG signals) and the R-peaks in real time.
  - Better modularize your signal processing flow. That is, please make each block as a function and then perform function calls.
  - Note that you can implement your signal processing modules in PC or in Arduino.
  - Can you display “Heart Rate” (Inverse of the RR interval) in real time?
  - Can you “beep” for each R peak
  - **The evaluation will depend on the average of the elapsed time for 100 loops of your signal processing and display (see ShortIntro2MatlabProfiler.pdf)**


Initialization
Data Buffer
Filtered Buffer
Filters
GUI
Read Data
FIFO into data buffer
Filtered raw ECG signal and find R-peaks
Plot for every second
?
Looping

Notes on Real Time Implementation: Time Profiling of Each Step

- **Sampling rate for data acquisition (Arduino side)**
- **Data transfer rate (Arduino to PC)**
- **FIFO handling**
- **Pre-processing: notch filtering (filter order), high pass filtering (filter order), squaring and flattening (LPF order), thresholding**
- **Peak finding**
- **Display**

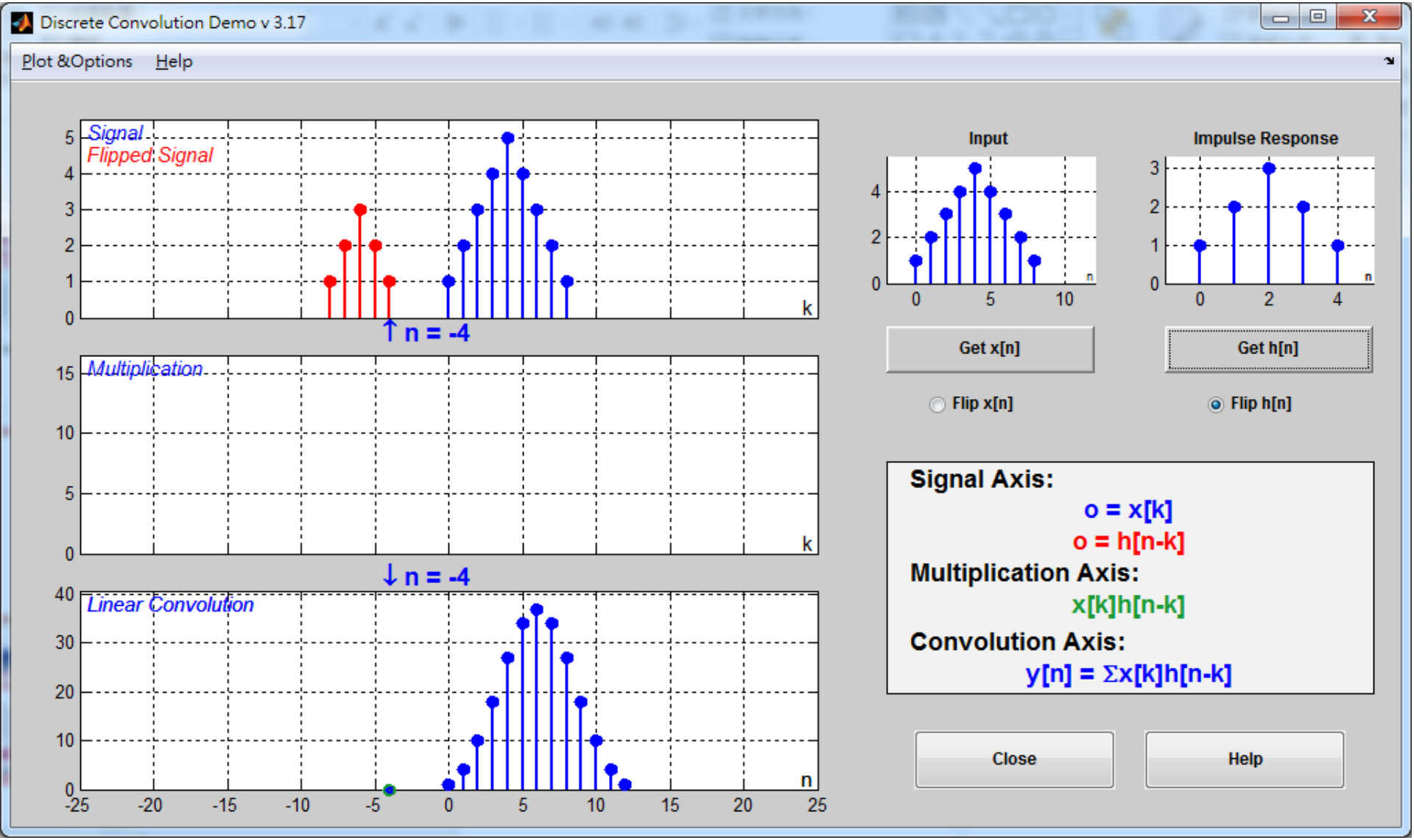
(See ShortIntro2MatlabProfiler.pdf, DisplayWithCorrectTiming.mov and DisplayWithIncorrectTiming.mov)

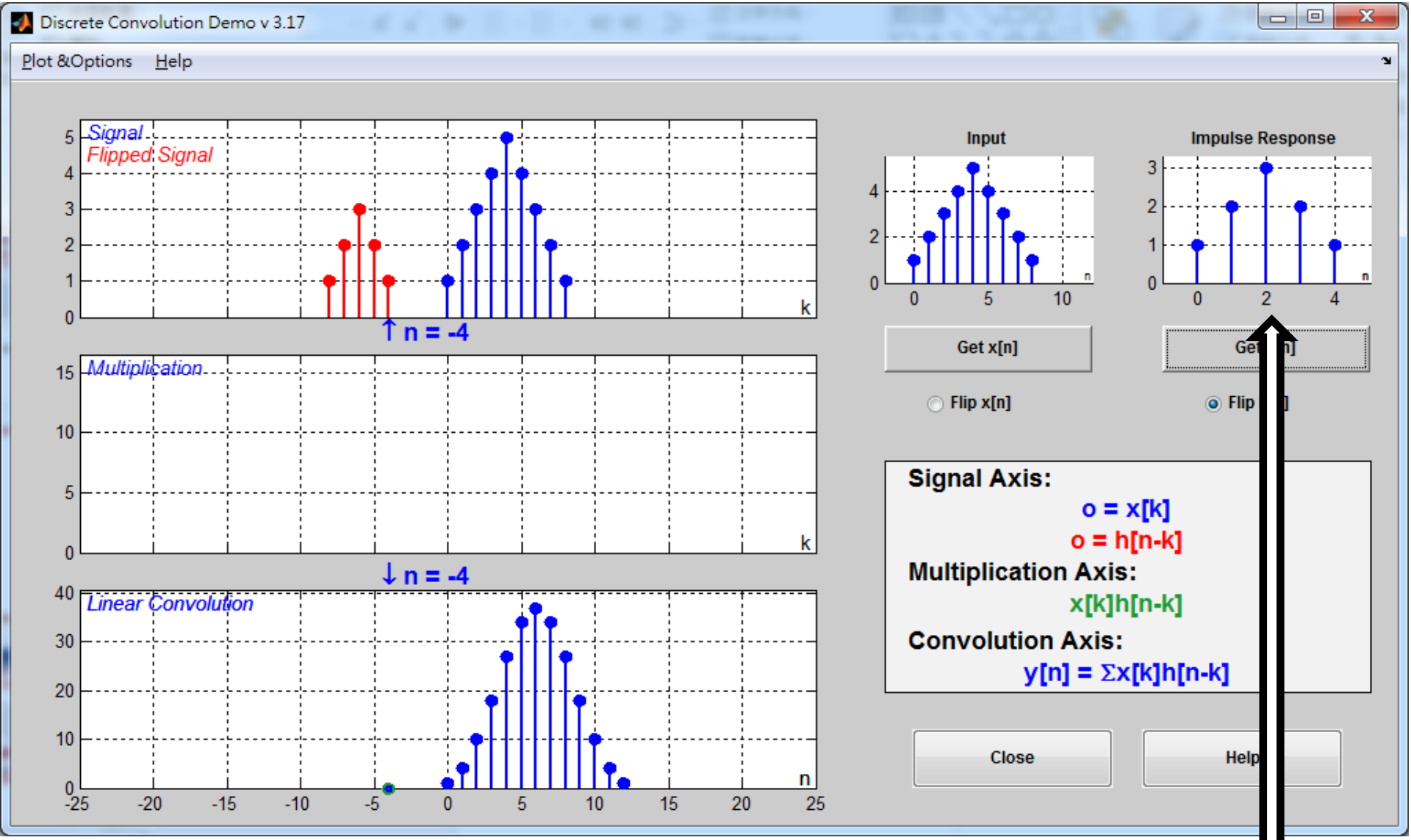
Task 2

- Find the R-peaks in MIT-BIH database.

(You have to take care "**group delay**" introduced by your linear phase FIR filtering in order to obtain the almost the same R-peak time as provided by the MIT-BIH database)

  - Detailed description about the provided data, please see the Lab 4 on the LMS e-learning system.
  - Please draw a table in your report. The first column is the name of the data set, the 2nd column is TP, the 3rd column is FN, and the 4th column is FP.
  - Please justify how you estimate your TP, FN, and FP and the precision when matching your results with the ground truth.

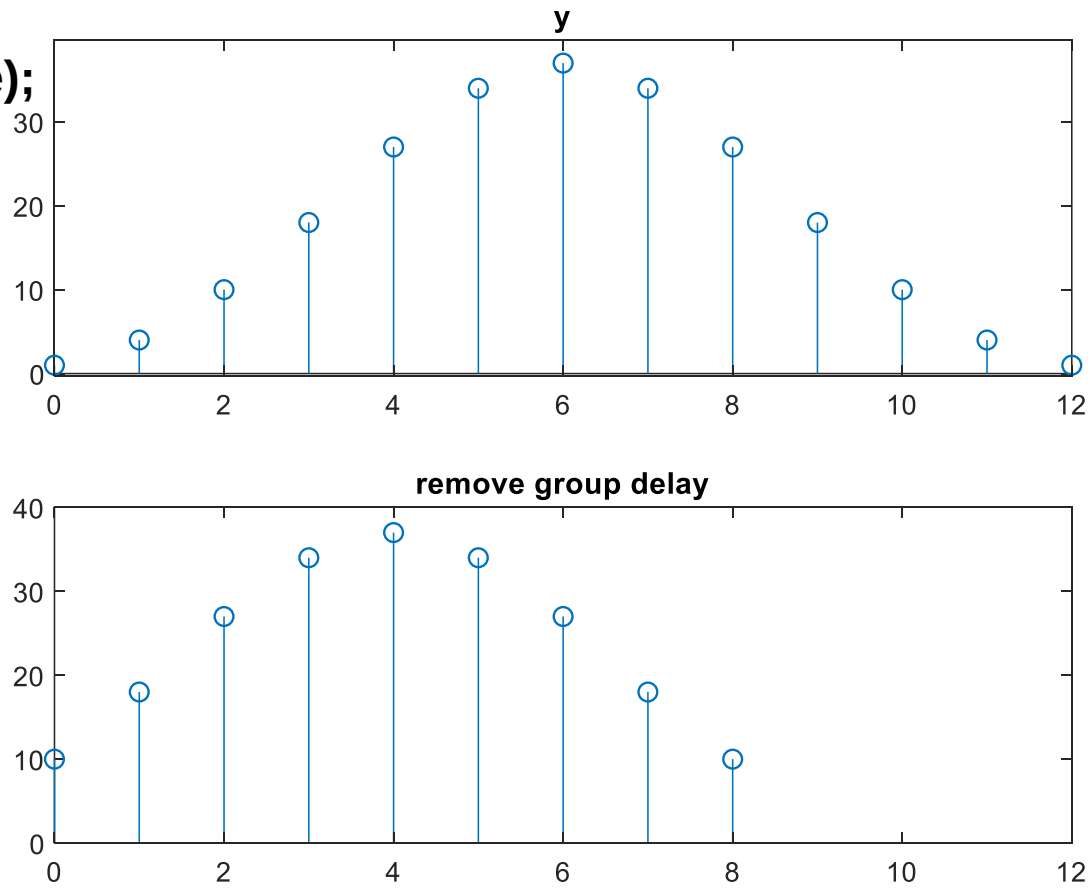

Discrete Convolution Demo v 3.17
Plot &Options
Help
Signal
Flipped Signal
k
n = -4
Multiplication
k
n = -4
Linear Convolution
n
Input
Impulse Response
Get x[n]
Get h[n]
Flip x[n]
Flip h[n]
Signal Axis:
o = x[k]
o = h[n-k]
Multiplication Axis:
x[k]h[n-k]
Convolution Axis:
y[n] = Σx[k]h[n-k]
Close
Help



Linear phase FIR filter

⟵ Group delay (你希望M是奇數還是偶數?)

```
>> x = [ 1 2 3 4 5 4 3 2 1];
>> h = [ 1 2 3 2 1];
>> y = conv(x,h);
>> y_same = conv(x,h,'same');
>> figure
>> subplot(2,1,1)
>> stem([0:(length(x)+length(h)-1)-1], y);
>> subplot(2,1,2)
>> stem([0:length(x)-1], y_same);
>> axis([0 12 0 40])
>> title('y')
>> title('remove group delay')
```



Potential Final Projects

可攜式光纖互動裝置產品

光源及互動感應控制模組微小化設計；利用無線傳輸將擷取到的生理數據視覺化，並作為長期記錄及醫療參考

整合呼吸心跳感應器

高功率微型LED及整合型聚光罩

數位式電子燈光色彩調控系統

內外時鐘 Clock Inside Out

作品所傳遞的訊息是「外在與內在世界時間的差異與層次」，當觀眾配戴著生理感應器看到時鐘時，就進入了有別於外在世界的時間和空間，雖然時針和分針仍然隨著世界的時間在運轉，但秒針是依著觀眾的心跳節奏前進，隨著觀眾的呼吸速度亮暗。

ECG, 呼吸, 九軸整合感測器 (Provided by Prof. Ma)

- 利用呼吸做鎮定訓練, 或是打坐訓練
- 9軸感測器中的某幾個感測器可以拿來做姿態辨識, 跌倒偵測, 活動量監測
- TI sensor Tag, 整合溫濕度, 光, 氣壓, 九軸等感測器, 可提供給同學做final project.

Link “Heart Rate” with “Audio” or/and “Video” Play

Blood Pressure Estimation with Photoplethysmography Only

Research Article | Vol. 7, No. 8 | 1 Aug 2016 | BIOMEDICAL OPTICS EXPRESS 3007

Biomedical Optics EXPRESS

Optical blood pressure estimation with photoplethysmography and FFT-based neural networks

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Abstract: We introduce and validate a beat-to-beat optical blood pressure (BP) estimation paradigm using only photoplethysmogram (PPG) signal from finger tips. The scheme determines subject-specific contribution to PPG signal and removes most of its influence by proper normalization. Key features such as amplitudes and phases of cardiac components were extracted by a fast Fourier transform and were used to train an artificial neural network, which was then used to estimate BP from PPG. Validation was done on 69 patients from the MIMIC II database plus 23 volunteers. All estimations showed a good correlation with the reference values. This method is fast and robust, and can potentially be used to perform pulse wave analysis in addition to BP estimation.

OCIS codes: (170.1610) Clinical applications; (170.3890) Medical optics instrumentation; (280.1415) Biological sensing and sensors.

運動科技 Dead Tennis String? Swing Vision?

- Swing Vision: 智慧網球訓練APP
- SwingVision: A.I. Scoring, Stats & Line Calling for Tennis (https://swing.tennis)