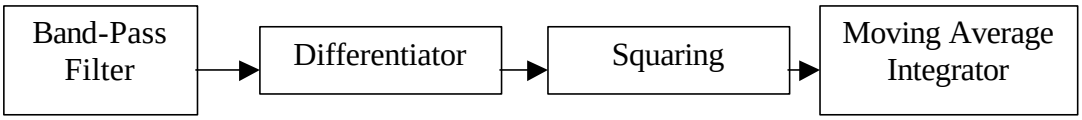
數位訊號處理概論: Biomedical Signal Processing
Term Project

Part I:

Part I focuses on QRS detection from ECG based on the method shown in the following block diagram (a.k.a. the Pan-Tompkins algorithm). Your task is to design the necessary filters, implement the algorithm on Matlab and study the performance. Finally, you should use the results to derive peak-to-peak heart rate.



Topic1: Implementation

The purpose of the band-pass filter is to emphasize the QRS-complex and attenuate other parts of ECG and noise. Hence, the band-pass filter should be designed to cover the QRS-complex frequency band. In `ECG1.mat`, you have typical resting ECG (sampling rate 200Hz) with very little noise. The typical low cut-off frequency ranges from 5 to 20 Hz and the typical high cut-off frequency ranges from 20 to 40 Hz. Design a band-pass filter that you think would give you the best performance. Plot the amplitude and phase responses of the filter. Explain your design requirements and what you have done to achieve these requirements. (Note: You can consider to investigate the spectrum to help you design the filter. You may also find Matlab functions `butter.m, filter.m, freqz.m, abs.m, angle.m, fft.m` and `psd.m` useful.)

Following the band-pass filter, implement the differentiator (hint: `diff.m`) and squaring operation. Finally, design and implement a suitable moving-average integrator (basically an FIR filter, in which all the coefficient are equal; the only parameter to choose is the filter length). Select a proper filter length by trying the procedures on `ECG1.mat`. Investigate and report what each step does for the signal.

The file `ECG2.mat` is with some interference. Apply the above algorithm to this data also. Investigate how the algorithm performs with different ECGs.

Topic 2: Heart rate estimation

Based on the results that you obtain, develop a method in Matlab to automatically estimate the heart rate. Explain your design procedures. (Note: You may consider simple thresholding and peak finding, or use more complex functions such as autocorrelation of the output of the above method.)

Part II:

The second part is paper survey. It is encouraged that you also use `ECG1.mat` and `ECG2.mat` to investigate issues addressed in the papers that you choose. Please focus on the papers that address signal processing problems in ECG. Examples are ECG data compression, adaptive noise cancellation, ECG classification, ..etc. You may start with IEEE Transactions on Biomedical Engineering and find other references from there. The outcome of part II should be a complete report.