BSP-Homework 4

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Problem-1

1. Implement the Pan-Tompkins method for QRS detection in MATLAB. You may employ a simple threshold-based method to detect QRS complexes as the procedure will be run off-line.

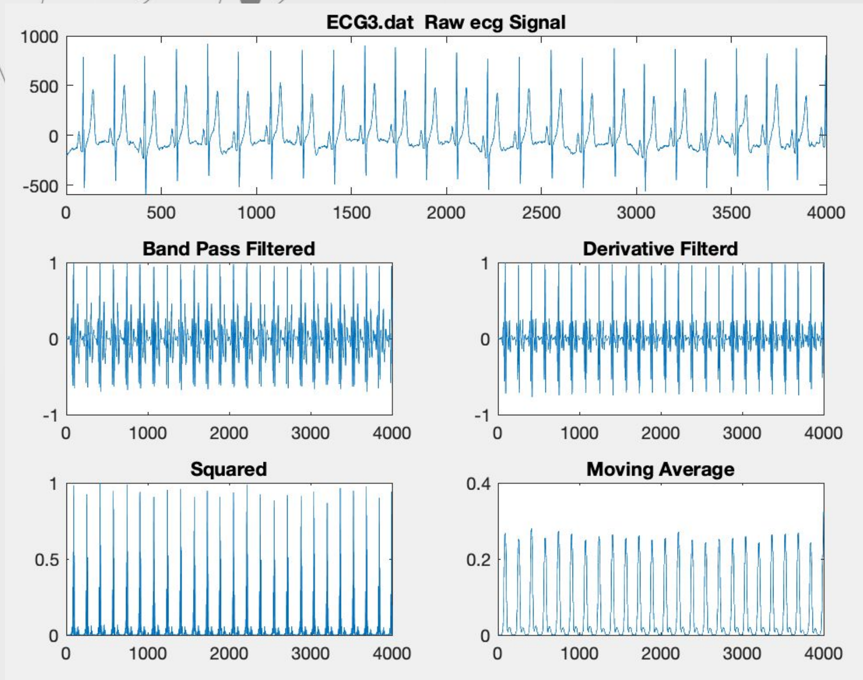
   Apply the procedure to the signals in the files ECG3.dat, ECG4.dat, ECG5.dat, and ECG6.dat, sampled at a rate of 200 Hz (see the file ECGS.m). Compute the averaged heart rate and QRS width for each record. Verify your results by measuring the parameters visually from plots of the signals.

- Signal ECG3, ECG4, ECG6 are more stable than ECG5, but each with different heart rate.
- ECG5 contains power line interference.

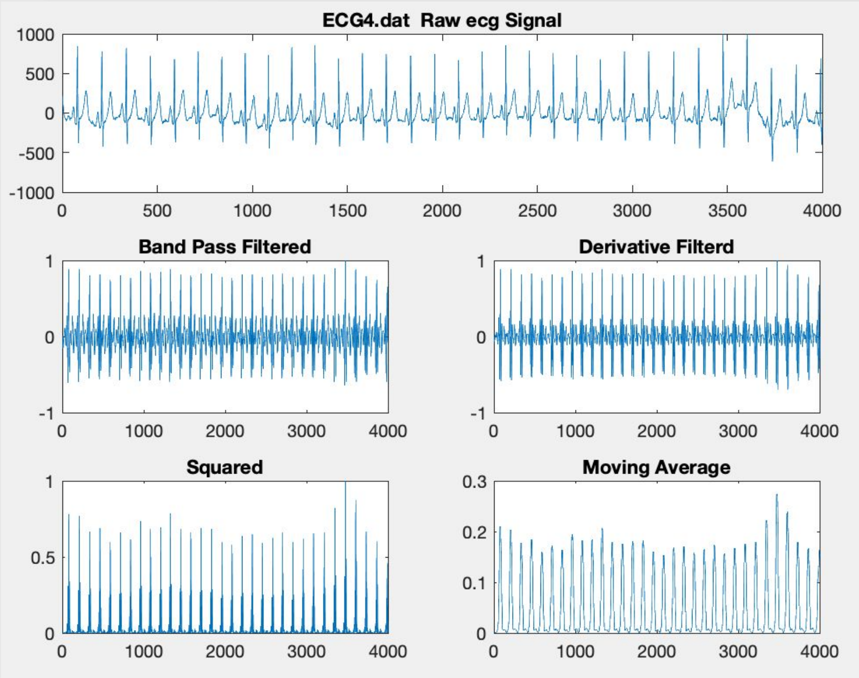
Methods

Use ECGS.m Read ECG → Low Pass Filter (12Hz) → High Pass Filter (5Hz) → Derivat ive Filter → Square → Moving Average (N=30 for 200Hz) → Find Peaks

Method

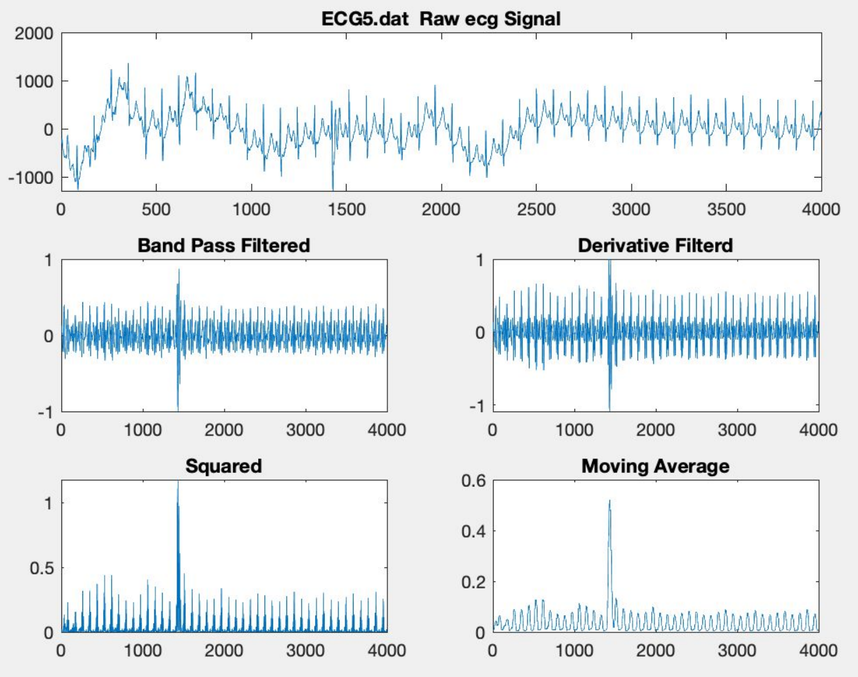


ECG3.dat Raw ecg Signal
1000
500
0
-500
0
500
1000
1500
2000
2500
3000
3500
4000
Band Pass Filtered
Derivative Filterd
1
0
-1
0
1000
2000
3000
4000
Squared
1
0.5
0
Moving Average
0.4
0.2
0

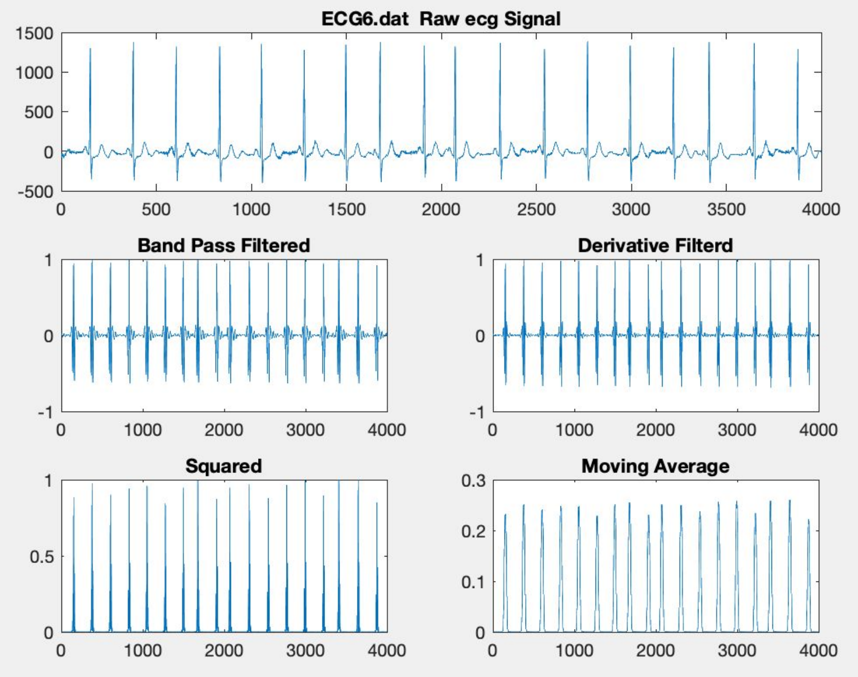


ECG4.dat Raw ecg Signal
1000
500
0
-500
-1000
0
500
1000
1500
2000
2500
3000
3500
4000
Band Pass Filtered
Derivative Filterd
1
0
-1
0
1000
2000
3000
4000
Squared
1
0.5
0
Moving Average
0.3
0.2
0.1
0

Method

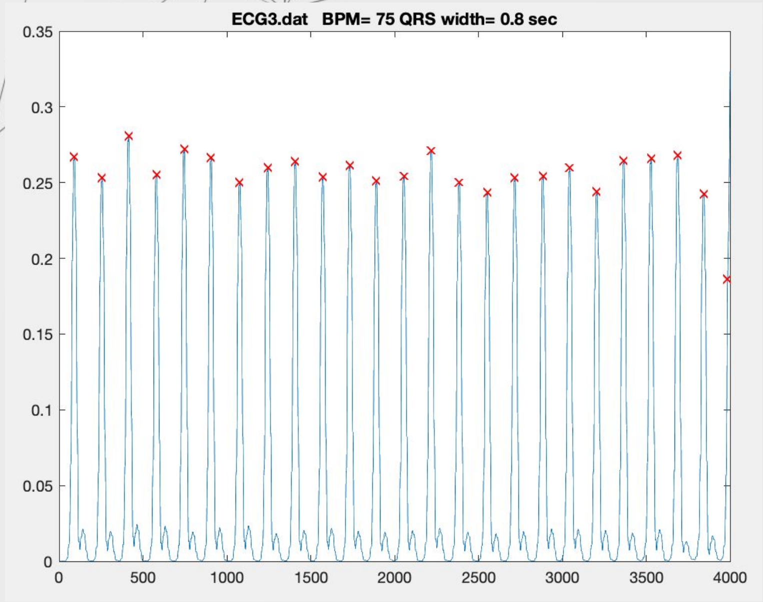


ECG5.dat Raw ecg Signal
Band Pass Filtered
Derivative Filterd
Squared
Moving Average

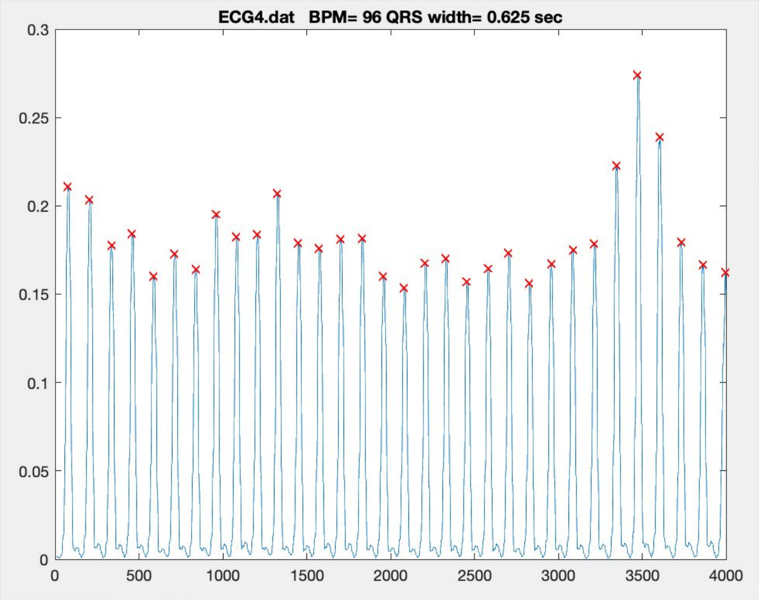


ECG6.dat Raw ecg Signal
Band Pass Filtered
Derivative Filterd
Squared
Moving Average

Results

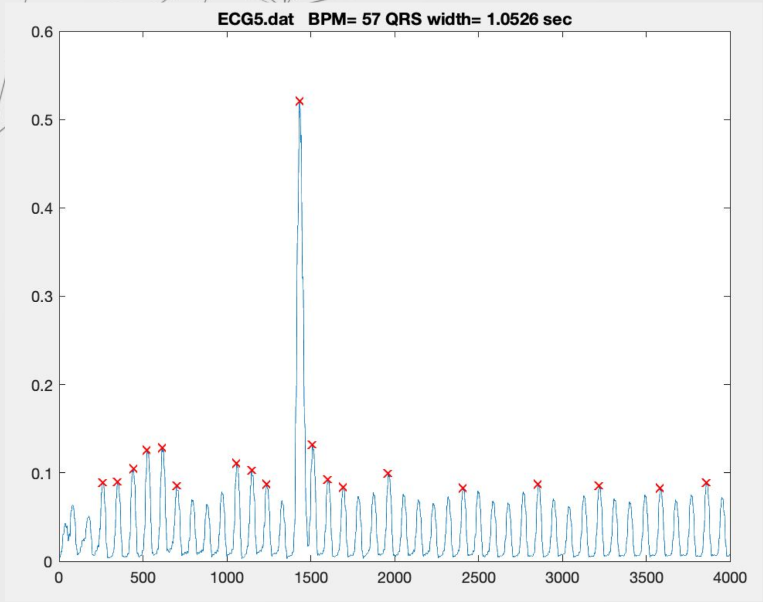


Visual Measure from Raw Data :
BPM=75
Width=0.816sec

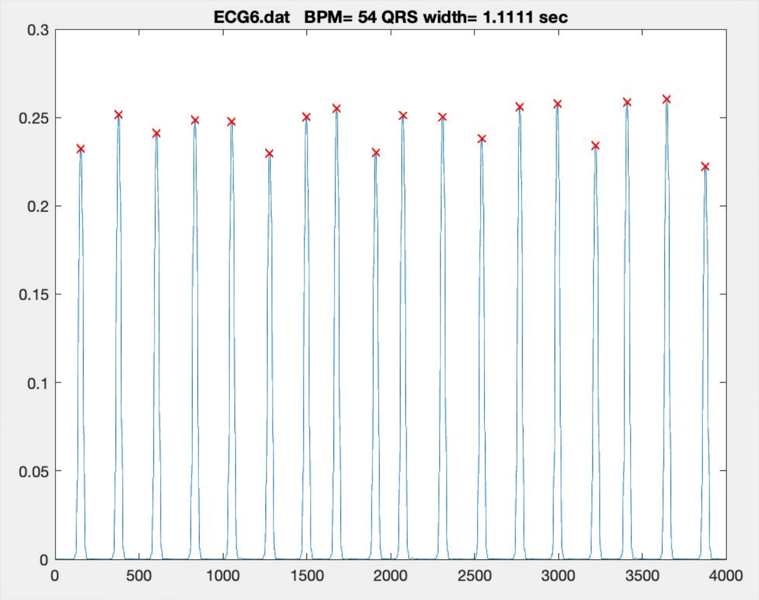


Visual Measure from Raw Data :
BPM=96
Width=0.63 sec

Results



Visual Measure from Raw Data:
BPM=132
Width=0.45sec



Visual Measure from Raw Data:
BPM=54
Width=1.11 sec

Discussion

- Using “findpeaks” function might have good performance in detection of regular peaks and calculate the correct BPM.
- But bad in QRS complex width evaluation and also bad in power line shifted, unusual ECG signal. (ECG5.dat)

Problem-2

1. Implement the Pan-Tompkins method for QRS detection in MATLAB. You may employ a simple threshold-based method to detect QRS complexes as the procedure will be run off-line.

   Apply the procedure to the signals in the files ECG3.dat, ECG4.dat, ECG5.dat, and ECG6.dat, sampled at a rate of 200 Hz (see the file ECGS.m). Compute the averaged heart rate and QRS width for each record. Verify your results by measuring the parameters visually from plots of the signals.

2. Implement the adaptive thresholding and searchback procedure to your P-T method and redo problem 1.

Methods

Use ECGS.m
Read ECG

Low Pass Filter
(12Hz)

High Pass Filter
(5Hz)

Derivative Filter

Square

Moving Average
(N=30)

Initialize
Signal level
Noise level
Threshold

Thresholding and decision

Search Back
(1.66 of averaged RR duration)

Methods

Initialize
Signal level
Noise level
Threshold

Thresholding and decision

Searchback (1.66 of averaged RR duration)

Initialize Signal level and Noise level as a percentage of the maximum and average amplitude of the integrated signal, respectively.

Methods

Initialize
Signal level
Noise level
Threshold

Thresholding and decision

Searchback
(1.66 of averaged RR duration)

$$SPKI = 0.125\,PEAKI + 0.875\,SPKI \quad \text{if } PEAKI \text{ is a signal peak;} \tag{4.15}$$

$$NPKI = 0.125\,PEAKI + 0.875\,NPKI \quad \text{if } PEAKI \text{ is a noise peak;}$$

$$THRESHOLD\ I1 = NPKI + 0.25(SPKI - NPKI); \tag{4.16}$$

Methods

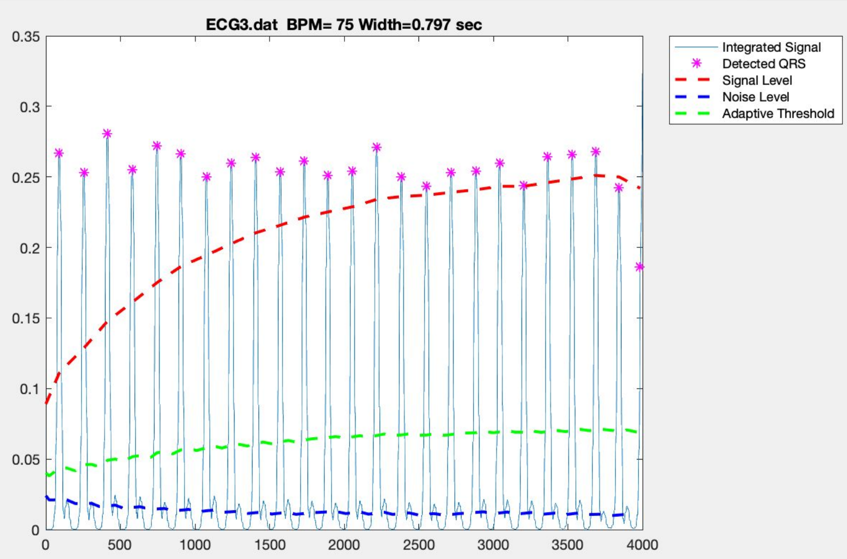
Initialize
Signal level
Noise level
Threshold

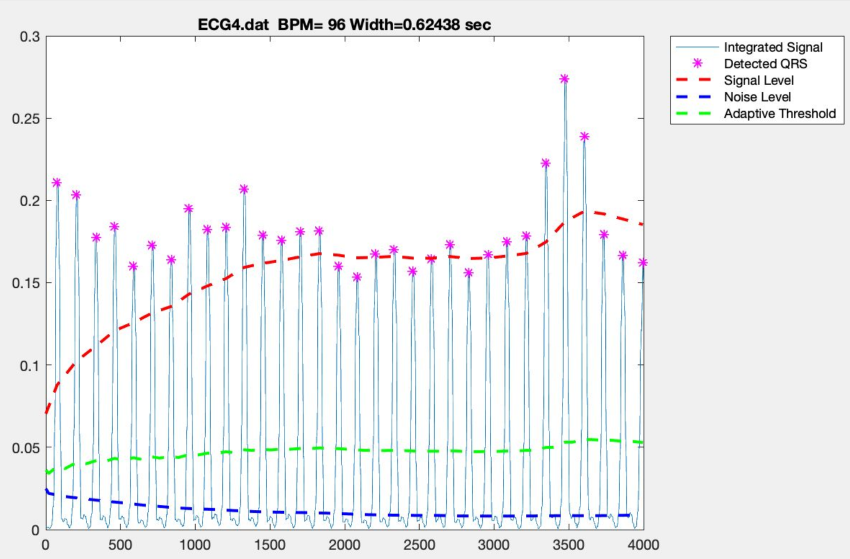
Thresholding and decision

Searchback
(1.66 of averaged RR duration)

$$THRESHOLD\ I2 = 0.5\ THRESHOLD\ I1.$$

Results

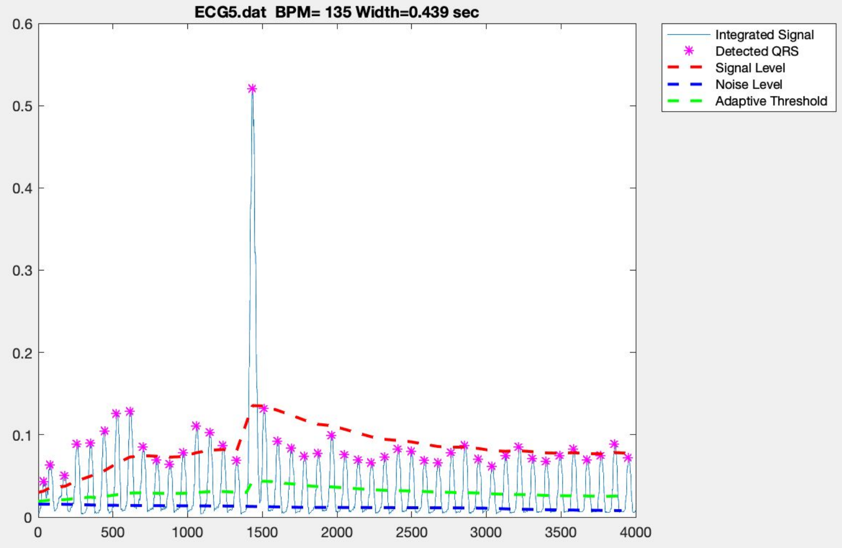


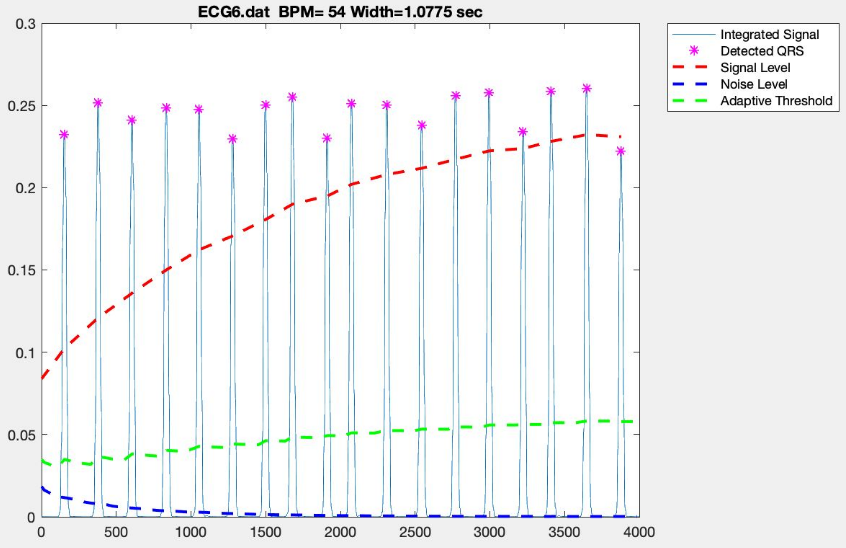


Visual Measure from Raw Data :
BPM=75
Width=0.816 sec

Visual Measure from Raw Data :
BPM=96
Width=0.63 sec

Results





Visual Measure from Raw Data:
BPM=132
Width=0.45 sec

Visual Measure from Raw Data:
BPM=54
Width=1.11 sec

Discussion

- Using adaptive threshold and searchback procedure will have a better result in processing signals with baseline shifted or unusual ECG signal.

Problem-3

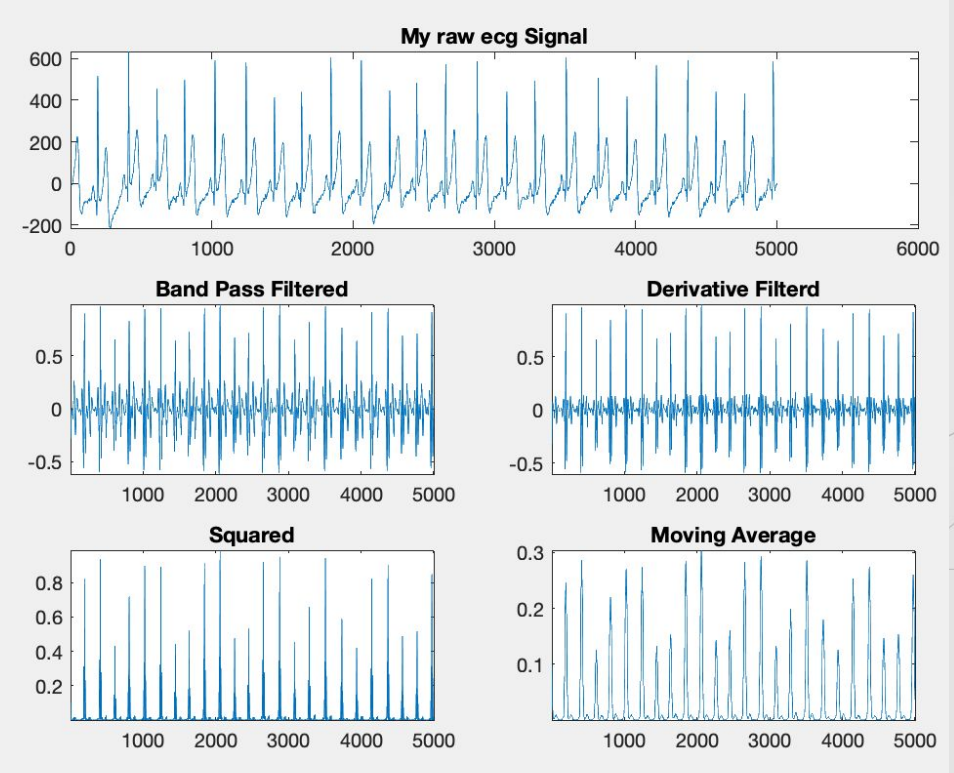
3. Apply your P-T method to your personal ECG.

- Load .mat data type as a struct, get values as .data (fs=250Hz)
- Cut noise signal at the beginning
- A bit power line interference

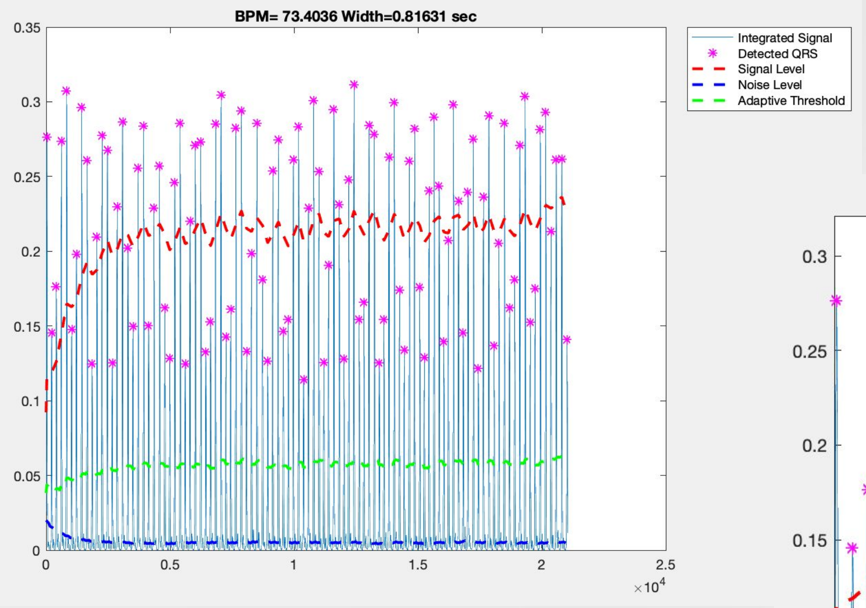
Methods

- Load ECG
- Low Pass Filter (12Hz)
- High Pass Filter (5Hz)
- Derivative Filter
- Square
- Moving Average (N=30)
- Initialize Signal level Noise level Threshold
- Thresholding and decision
- Search Back (1.66 of averaged RR duration)

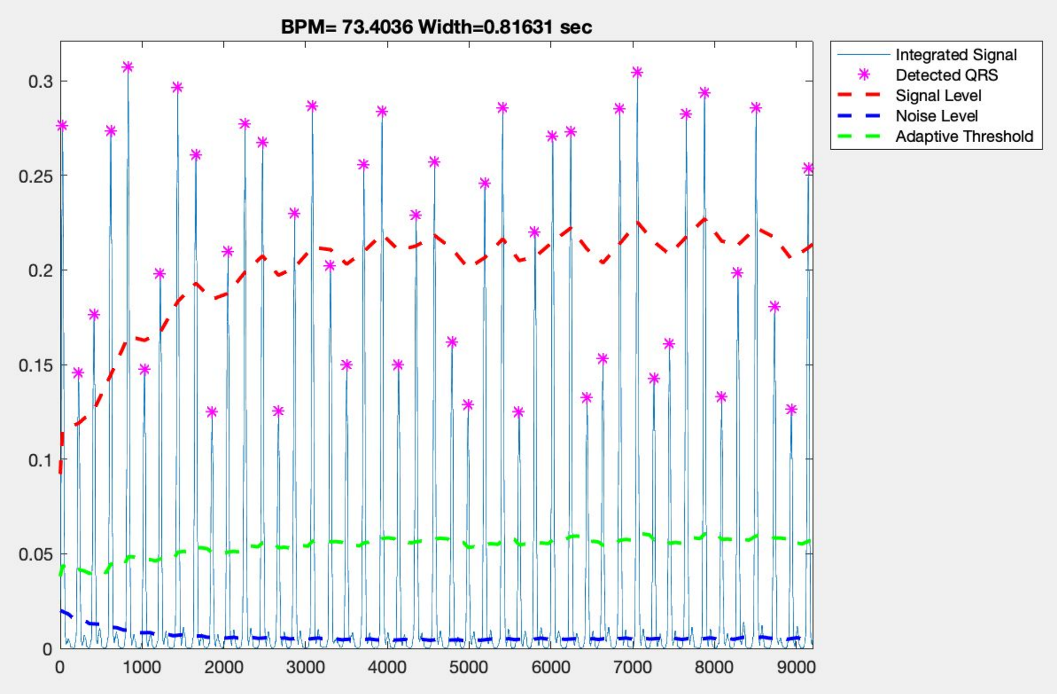
Results


My raw ecg Signal
600
400
200
0
-200
0
1000
2000
3000
4000
5000
6000
Band Pass Filtered
0.5
0
-0.5
1000
2000
3000
4000
5000
Derivative Filterd
0.5
0
-0.5
1000
2000
3000
4000
5000
Squared
0.8
0.6
0.4
0.2
1000
2000
3000
4000
5000
Moving Average
0.3
0.2
0.1
1000
2000
3000
4000
5000

Results-Adaptive Thresholding



Visual Measure from Raw Data:
BPM=72
Width=0.8sec



Discussion

- Although my signal contains a baseline shifting, adaptive thresholding can correctly measure my BPM.
- We can clearly observe the floating of the signal level and the threshold while doing adaptive thresholding.

THANKS