SEB4233
Biomedical Signal Processing

ECG Analysis 1: QRS Detection

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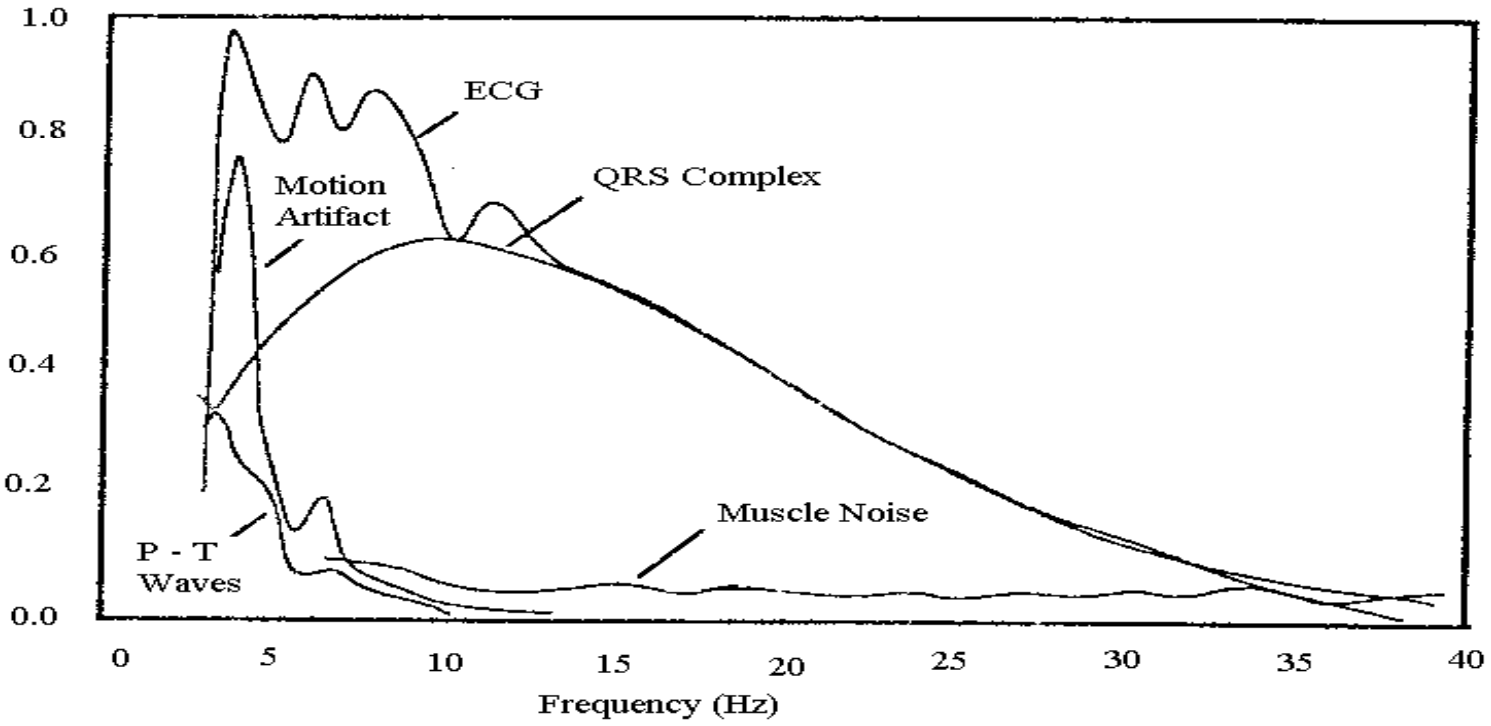
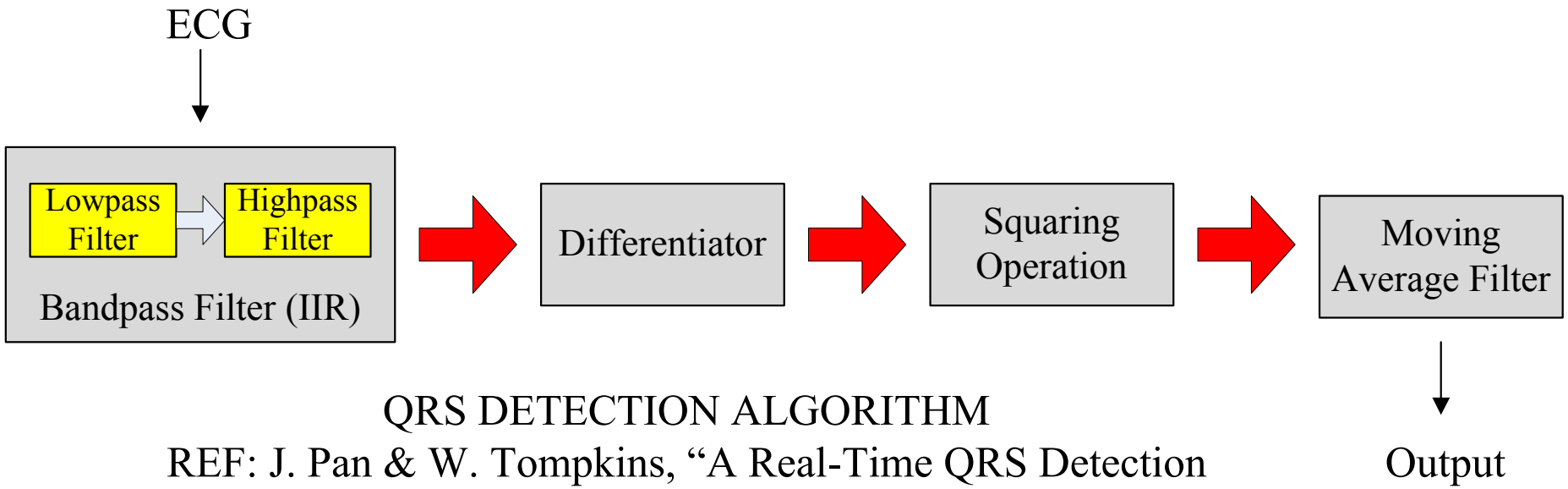
ECG Signal Characteristics

- Relative power spectrum of QRS complex, P and T waves, muscle noise and motion artifacts.



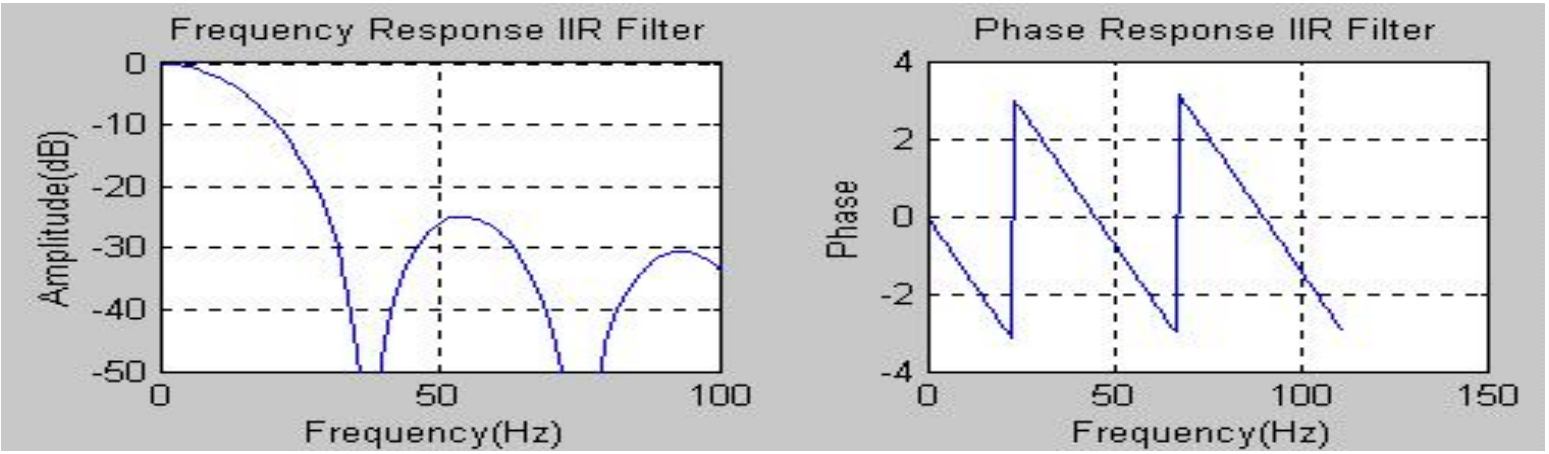
QRS Detection Algorithm



QRS DETECTION ALGORITHM
REF: J. Pan & W. Tompkins, "A Real-Time QRS Detection Algorithm", IEEE Transactions on Biomed. Eng.

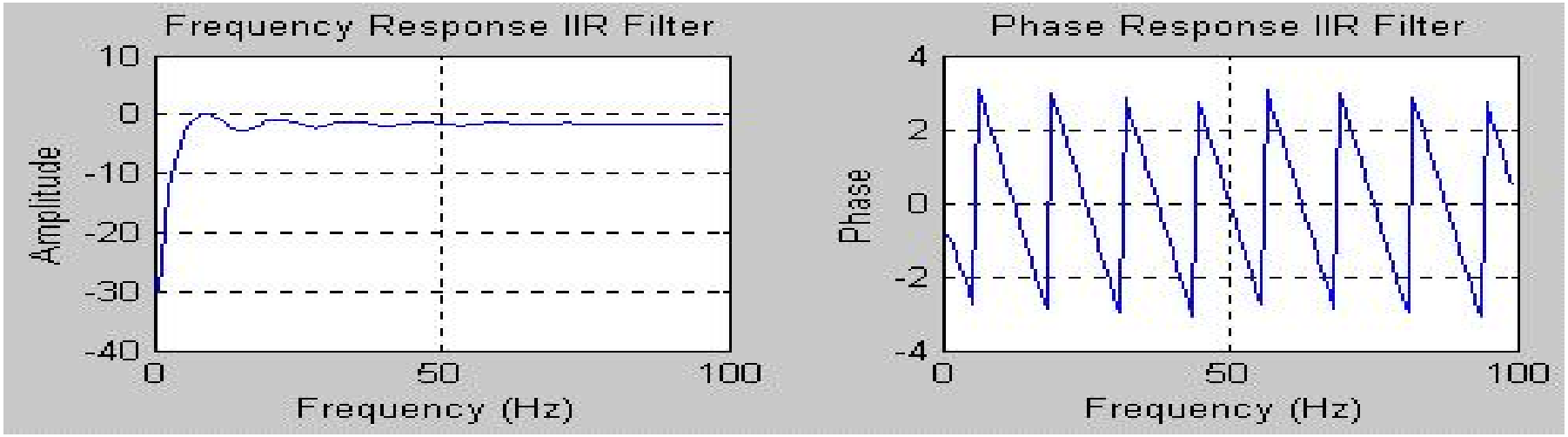
QRS Detection Algorithm...(cont)

- Bandpass filter-cascaded lowpass filter and highpass filter to isolate the predominant QRS energy centered at 10 Hz. Energy of QRS is between 5Hz-15Hz. (Thakor et. al., 1983)
- Lowpass filter:Eliminate noise such as the EMG and 50Hz power line noise
- Cutoff frequency=11Hz
- $y[n] = 2y[n-1] - y[n-2] + x[n] - 2x[n-6] + x[n-12]$



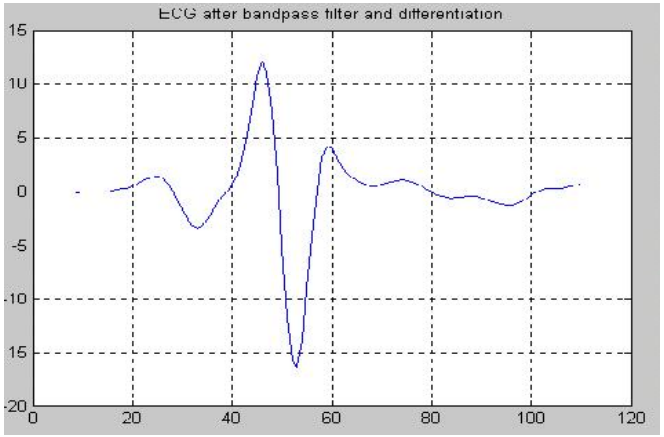
QRS Detection Algorithm...(cont)

- Highpass filter:
- Eliminate motion artifacts, P wave and T wave .
- Cutoff frequency = 5Hz
  - $y[n] = y[n\text{-}1] - x[n]/32 + x[n\text{-}16] - x[n\text{-}17] + x[n\text{-}32]/32$

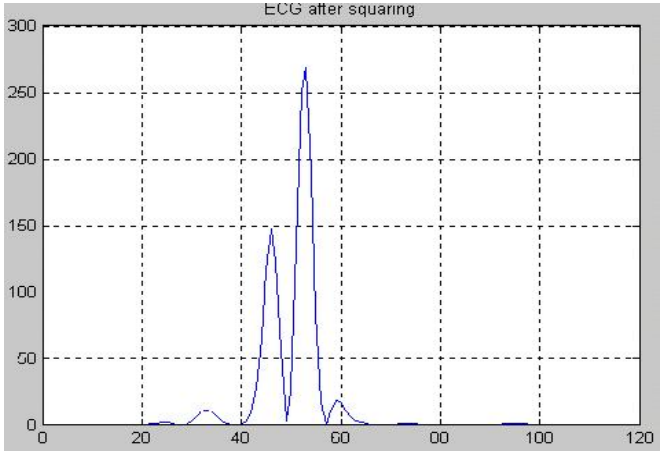


QRS Detection Algorithm...(cont)

- **Differentiation:** To obtain information on slope and overcome the baseline drift problem.
- Accentuates QRS complexes relative to P & T wave
  - $8y[n] = 2x[n] + x[n-1] - x[n-3] - 2x[n-4]$

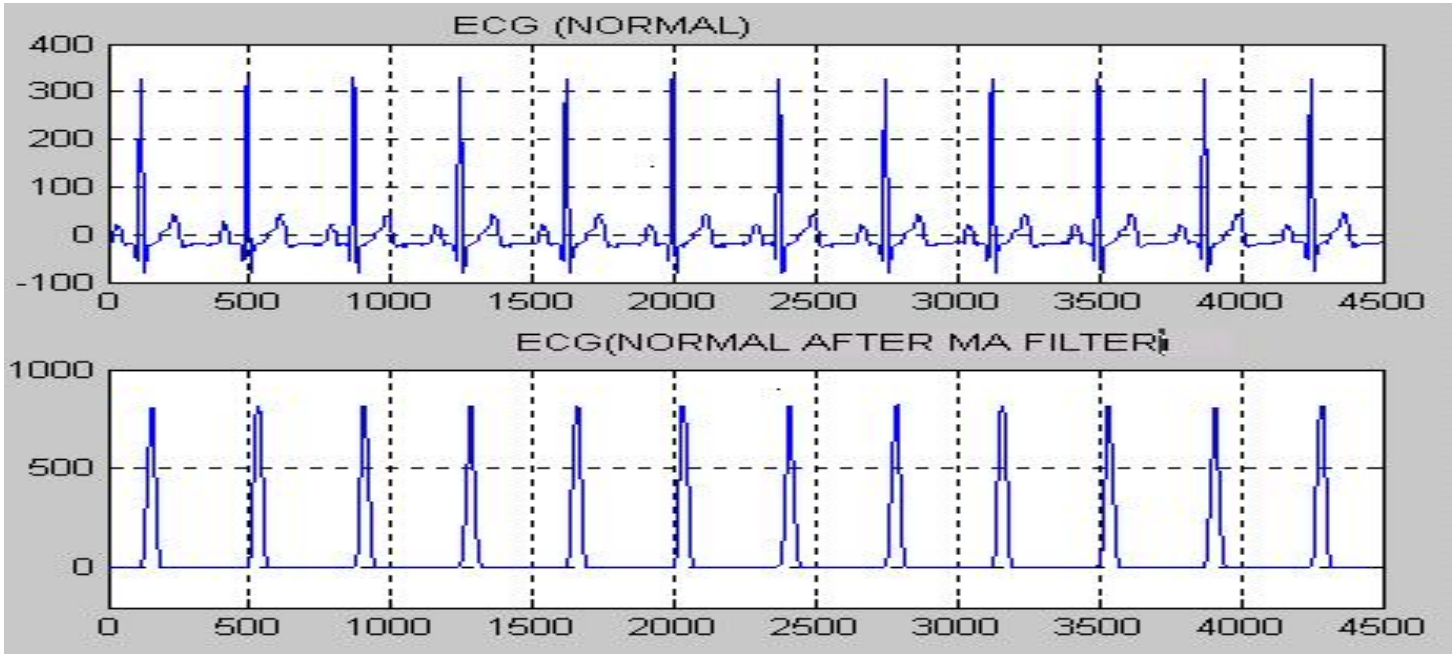


- **Squaring**
- Emphasizes the higher frequency component and attenuates the lower frequency component.
  - $y[n] = x[n]^2$

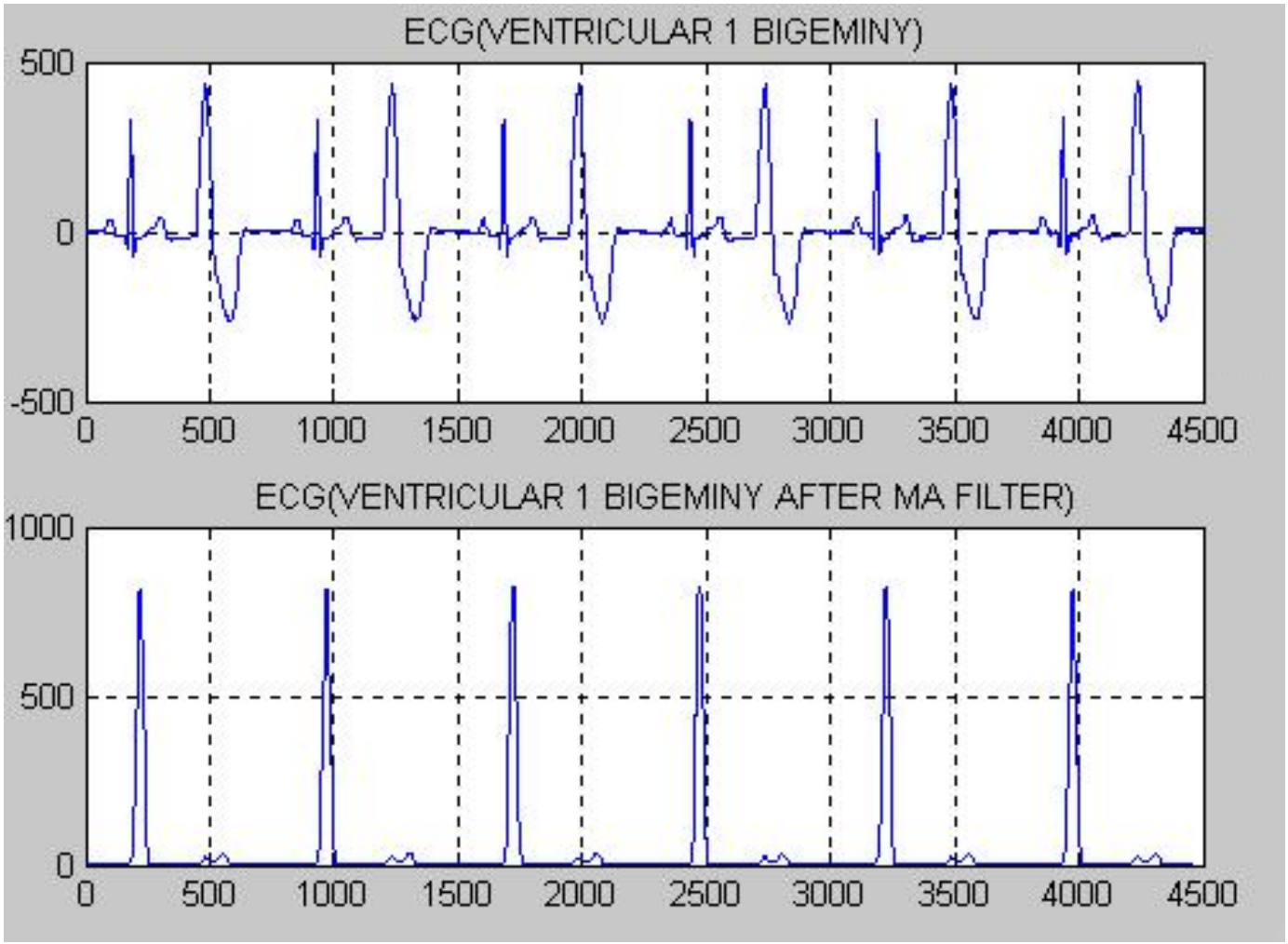


QRS Detection Algorithm...(cont)

- **Moving Average filter**
- Acts as a smoother and performs a moving window integrator over 150ms.
  - $y[n] = (x[n-(N-1)]) + x[n-(N-2)] + \ldots\ldots\ldots\ldots + x[n])/N$
    - » N:length of MA filter



QRS Detection Algorithm...(cont)



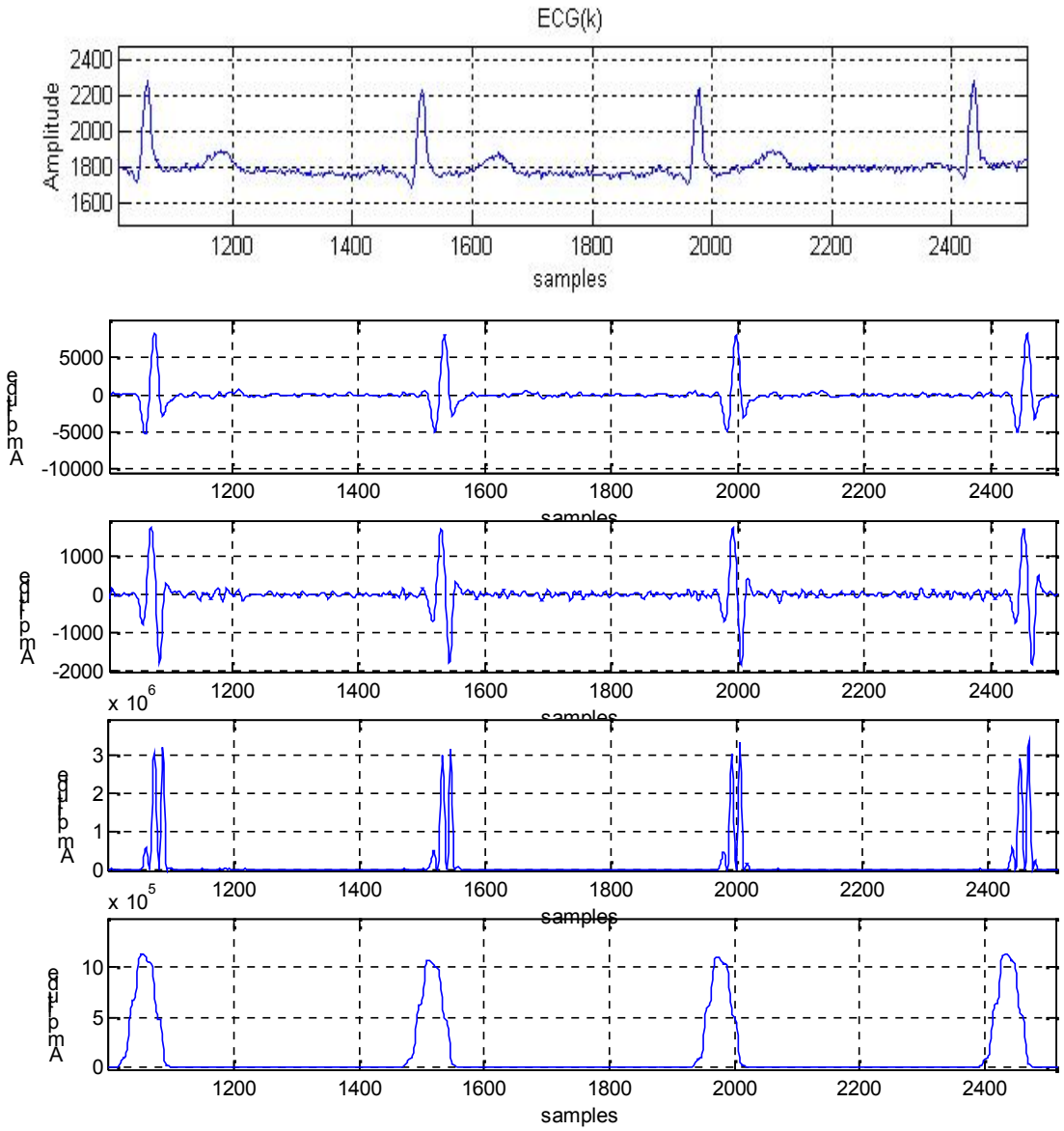
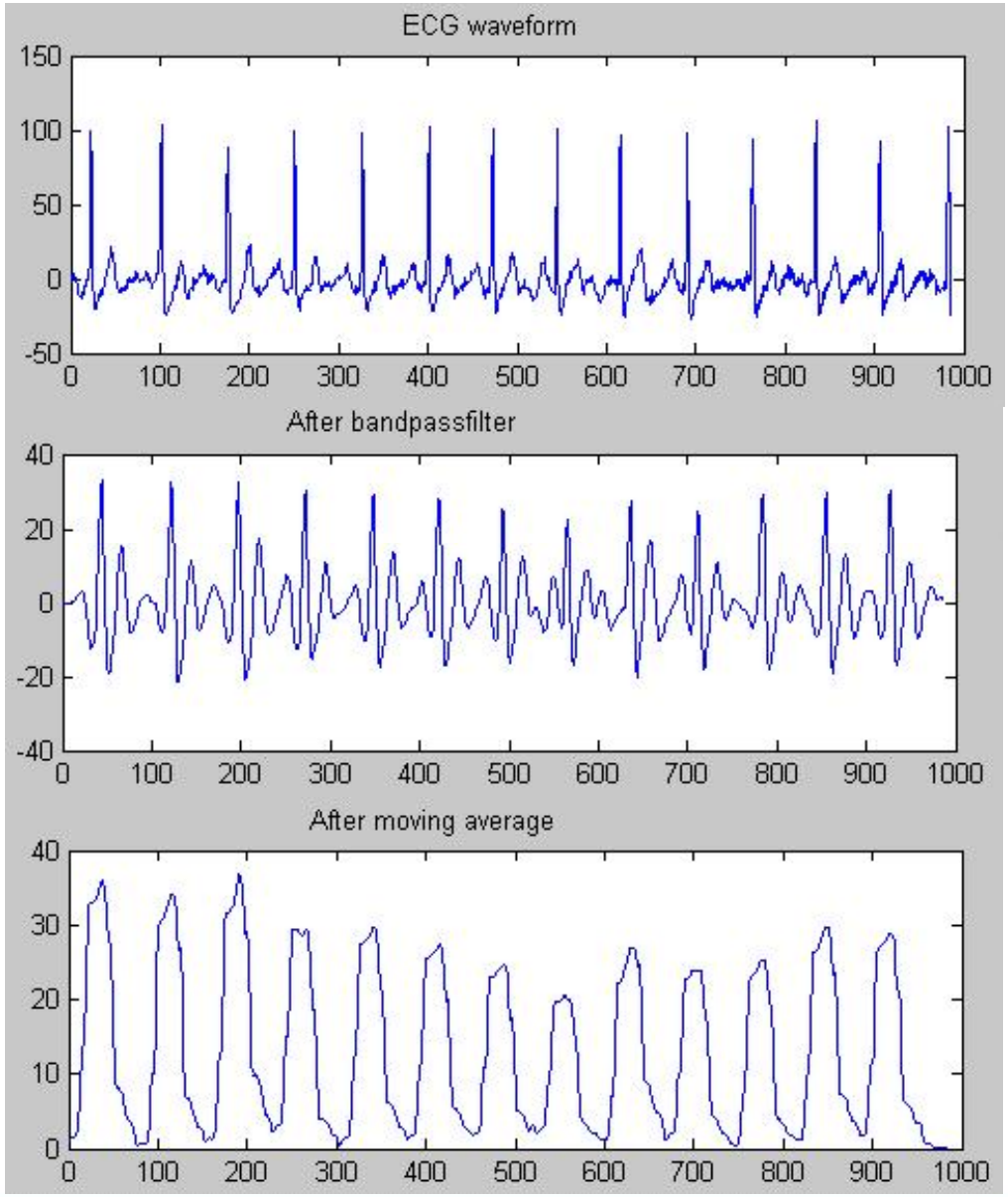


Figure: a.) The digitized ECG signal, ECG (k). Effects of b.) after band pass filtering. c.) after band pass filtering and differentiating. d.) after band pass filtering, differentiating and squaring. e.) the final process; after band pass filtering, differentiating, squaring and moving average filter.

Data from HUKM



QRS Detection Algorithm...(cont)

- The QRS complex is detected when the slope amplitude is within the threshold.
- Heart rate is calculated according to the formulae below:

➢ Heart rate(bpm)= (60 000*f_s)/R-R interval(ms)
(f_s = 450Hz)