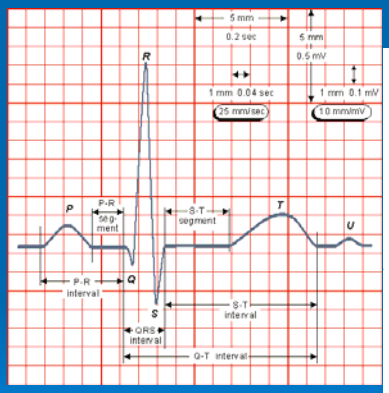
Noise in ECG and how to deal with it

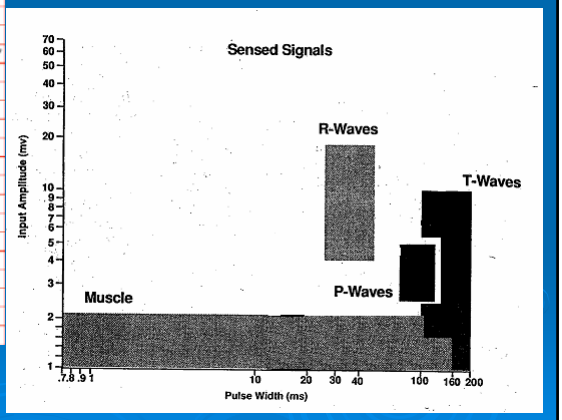
Djordje Popovic, MD

Outline

- Frequency characteristics of ECG
- Most common sources of noise, characteristics and examples
- How to deal with some of them (filtering techniques)

Frequency characteristics of normal ECG



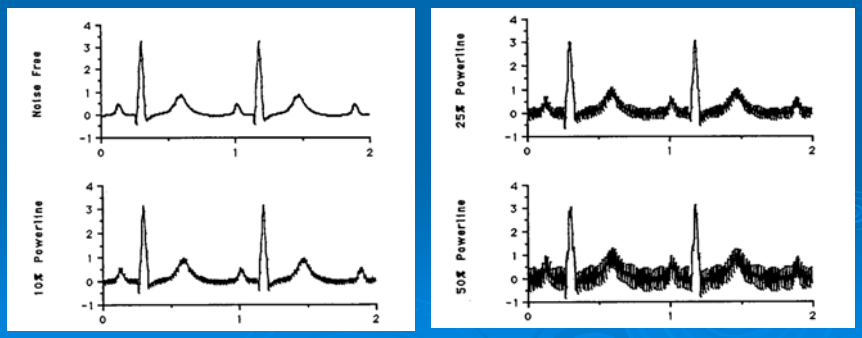


Sources of noise

- Power line interference
- Electrode contact noise, baseline drift and motion artifacts
- EMG from the chest wall
- Instrumentation noise
- Electrosurgical noise

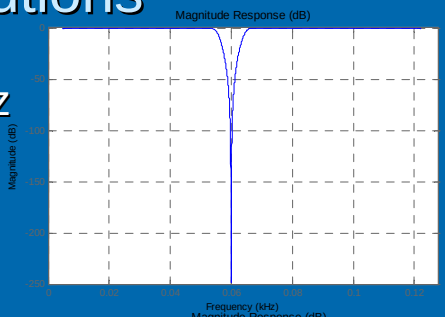
Power line interference

- 60 Hz & multiples
- Up to 50% of QRS amplitude



Solutions

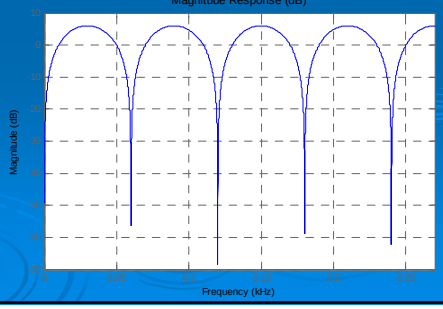
- Notch filter at 60 Hz



- Comb filter

Sampl.rate=n x 60 Hz

Y(i)=X(i)-X(i-n)



Adaptive filtering of power hum

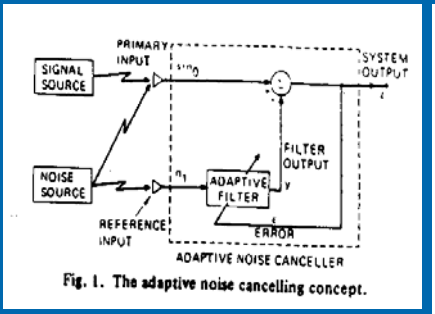


Fig. 1. The adaptive noise cancelling concept.

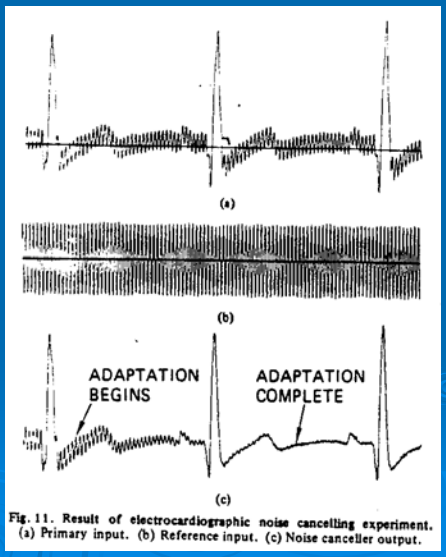
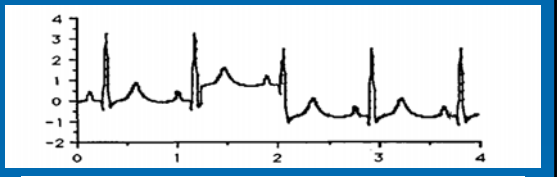


Fig. 11. Result of electrocardiographic noise cancelling experiment. (a) Primary input. (b) Reference input. (c) Noise canceller output.

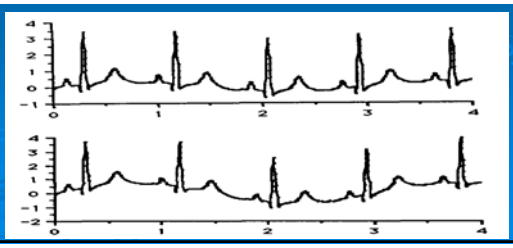
Electrode contact noise

- Loose contact

- Motion artifact

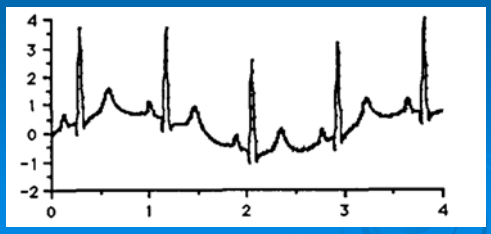


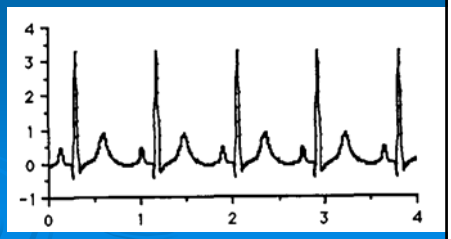
- Baseline drift due to respiration



Solutions

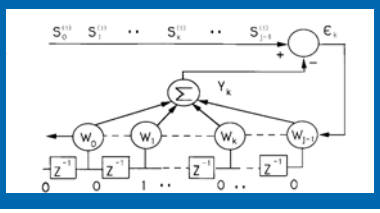
- Typically <0.5 Hz signals (except for the abrupt shifts due to motion)
- High-pass filtering with cut-off frequency at ~ 0.5Hz, realized in hardware or software

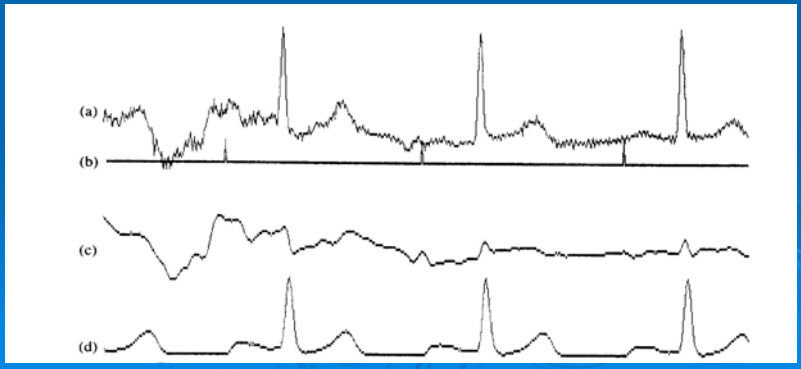




Abrupt motion artifact cancellation

- Adaptive recurrent filtering





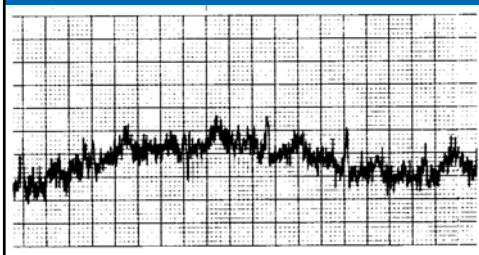
EMG

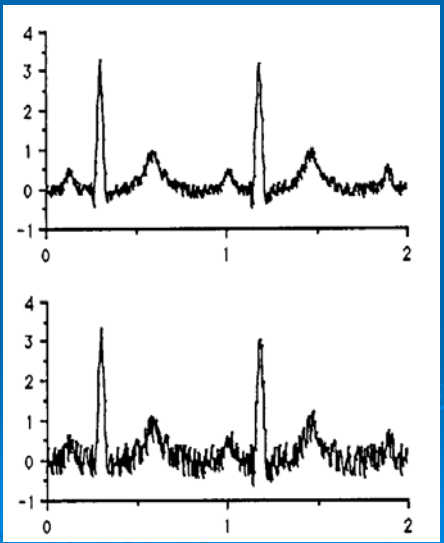
- Amplitude

~ 10% ECG

- Broadband

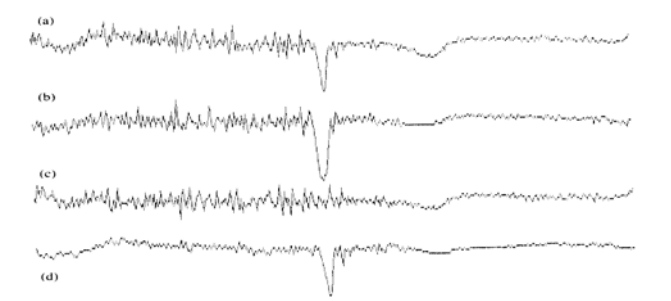
(20 – 1000 Hz





Solutions

- Low-pass filter with cut-off frequency >40Hz
- Adaptive filter with aVf as primary and aVr-aVl as reference



Summary

- Many different sources of noise, frequency content of some of them overlaps with ECG
- Limited capabilities of linear filtering
- Final solution dependent on each particular case, and our goals

Questions?

Use of adaptive filters in ECG processing

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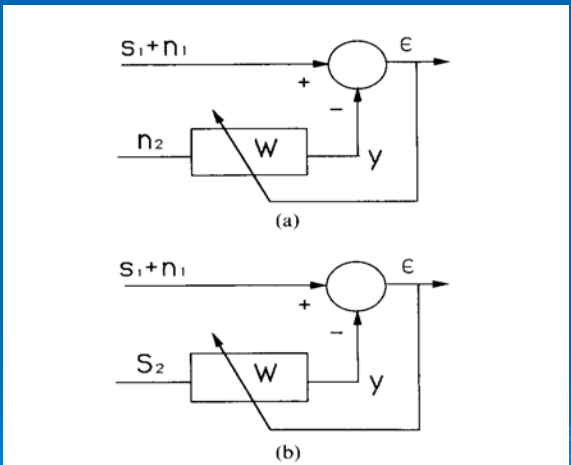
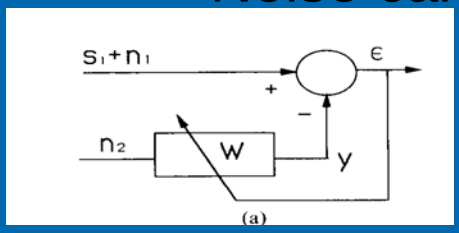
Structure of an AF

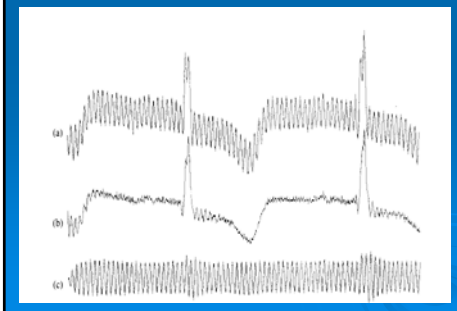


- S1/S2 or n1/n2 need not be the same, only correlated in some way !!

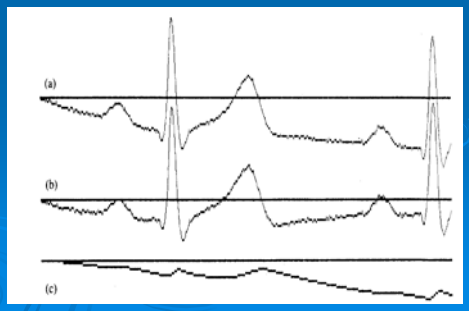
Noise cancellation



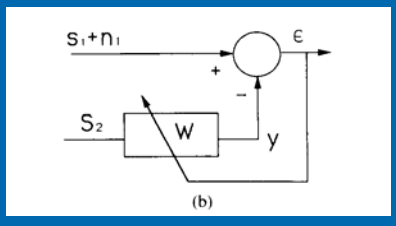
- Power line interference

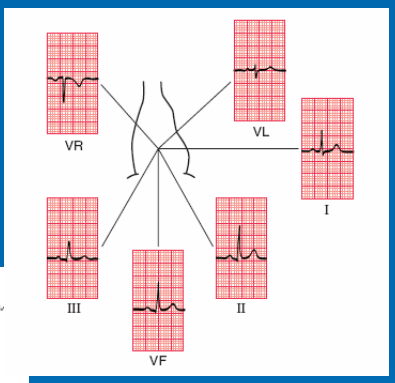


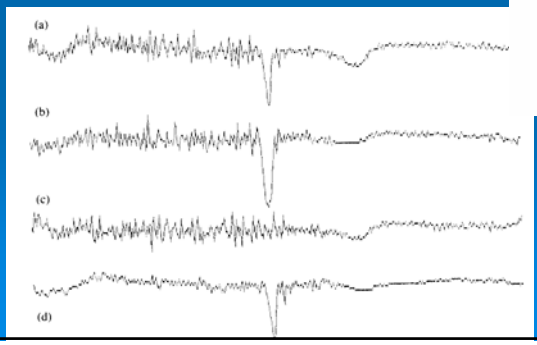
- Baseline drift



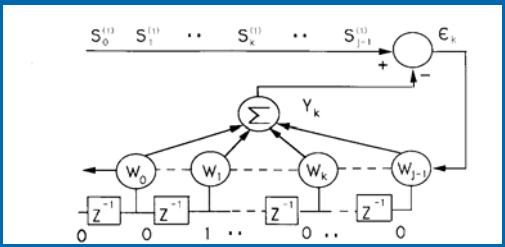
EMG cancellation





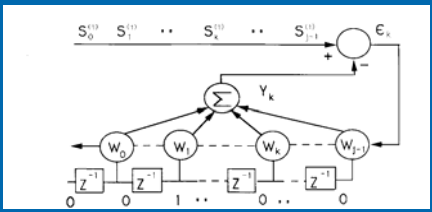


Arrhythmia detection

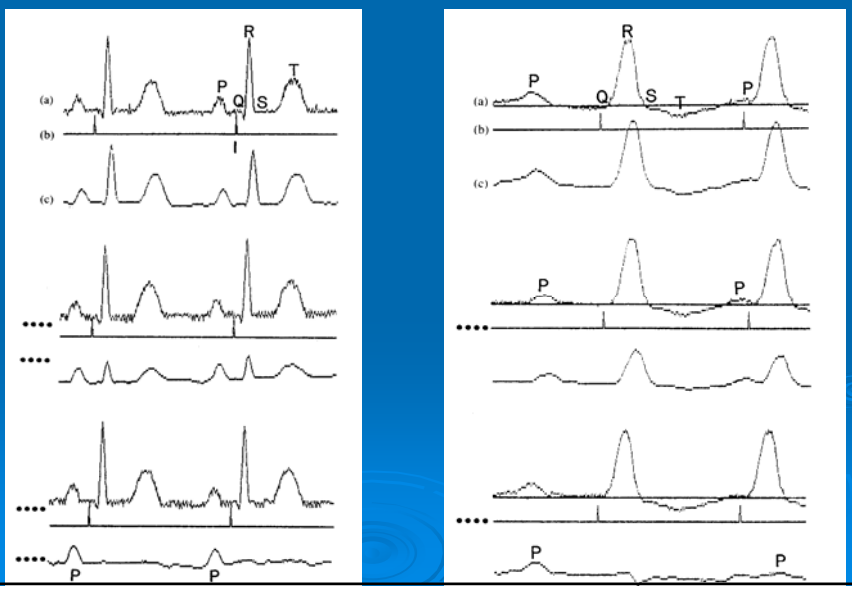


- Goal: to cancel normal QRS complexes, and to analyze the signal that remains after the cancellation

Detection of ectopic beats



P-wave analysis



Atrial fibrillation and/or flatter