Tampere University

Assignment 2: Spectral analysis of EEG

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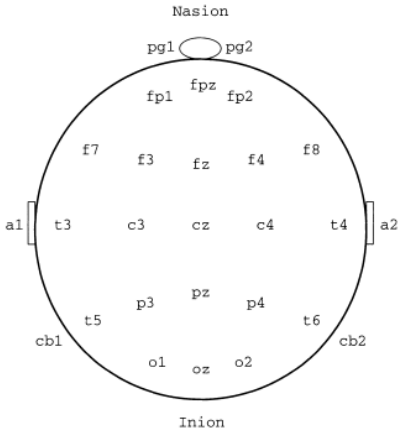
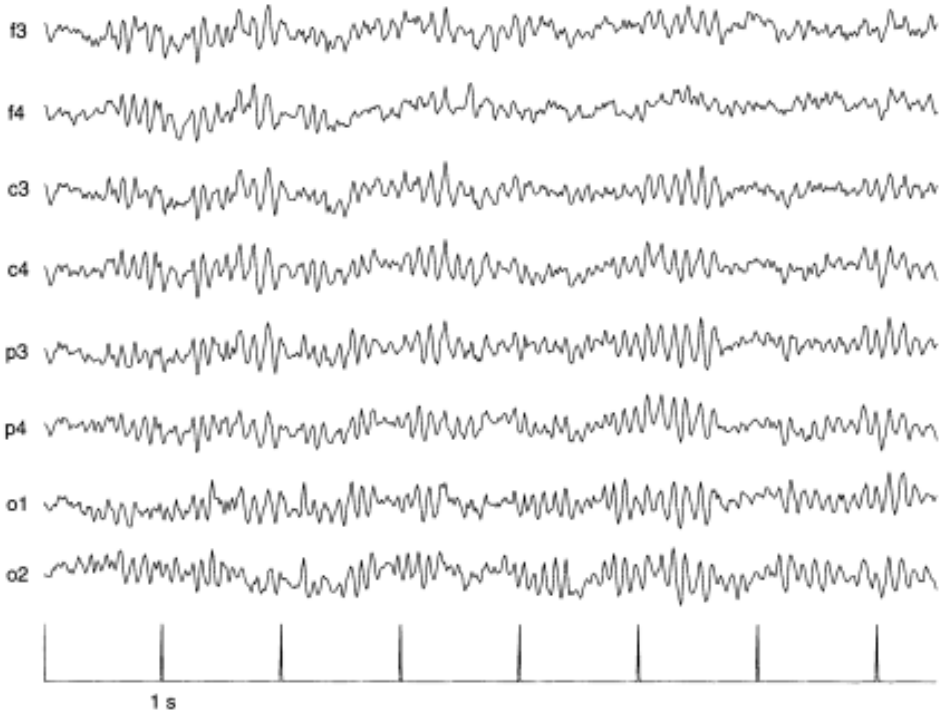
Two different datasets: sleep EEG from physionet, or awake EEG measured in HeAT lab!

- If you have measured EEG in the lab session (or will do so this week), use that dataset in the analysis of this computer assignment. If you chose not to measure EEG, use the data provided in Physionet.
  - Readedf_EX1.m is only used for the physionet data!
- The analysis of the assignment is the same regardless of which data you use, but the results differ since other signal is related to sleep and our own signal is representing the effect of alpha rhythm.
- Remember to mention in the report which data you used in your analysis! Remember to also carefully check, which is the correct sampling frequency of your study.

EEG signal

- Electrical activity of the brain
  - Electrodes placed along the scalp





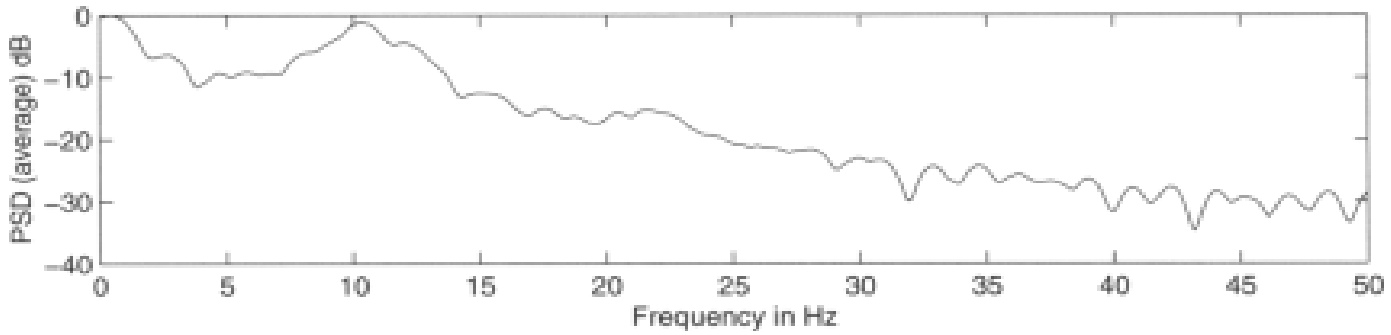
EEG signal

- The frequency bands of EEG:

Band	Frequency (Hz)	Normally in adults
Delta	< 4	Deep sleep
Theta	4-8	Drowsiness, at the beginning of sleep
Alpha	8-13	Resting, closing the eyes
Beta	> 13	Active thinking

Power spectral density

- Characterization of the frequency content of the signal



Power spectral density

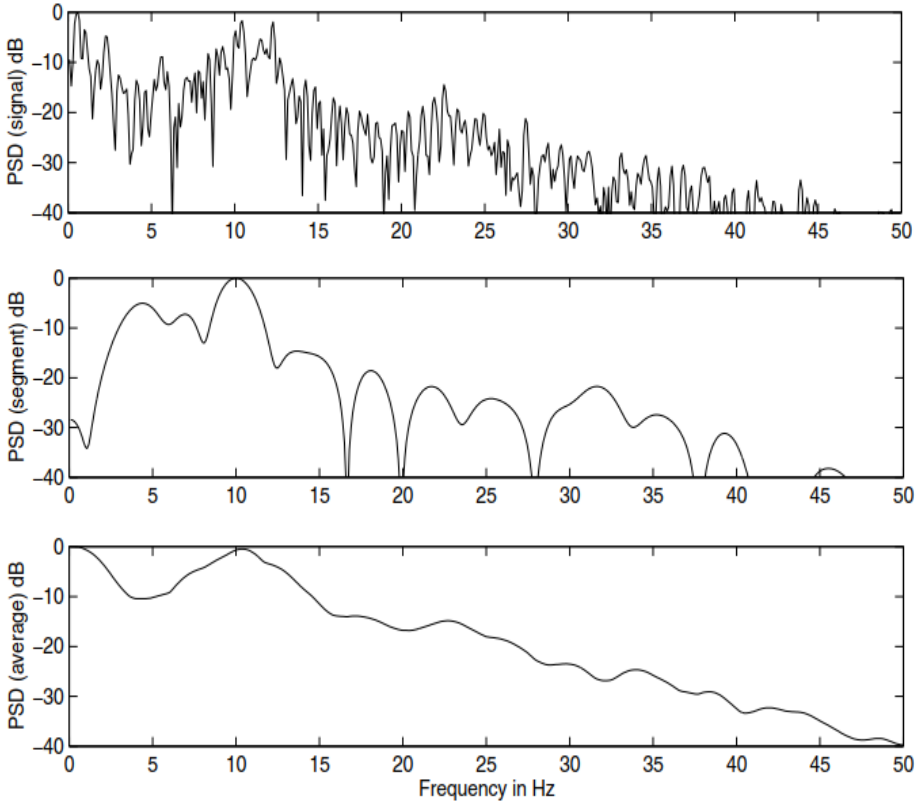
- The simplest technique is to square the discrete Fourier transform of a signal
  - The periodogram
  - Spectral leakage
    - some energy leaking to frequencies where there should not be any
- Welch's method:
  - reduces noise in the estimated power spectra but reduces also the frequency resolution

Power spectral density

- Welch's method:
    1. divide the time series into overlapping segments
    2. window the segments
    3. compute a periodogram of each windowed segment
    4. average the power spectral density estimates

➢ the estimate of the power spectral density (PSD)

Example of Welch estimate of the PSD



PSD of the entire signal i.e. one segment with Hann window (FFT calculation)

- The Hann window has not significantly removed the peaks and valleys in the PSD because the window length that is large

PSD of the 11th segment (segment length = 64 samples)

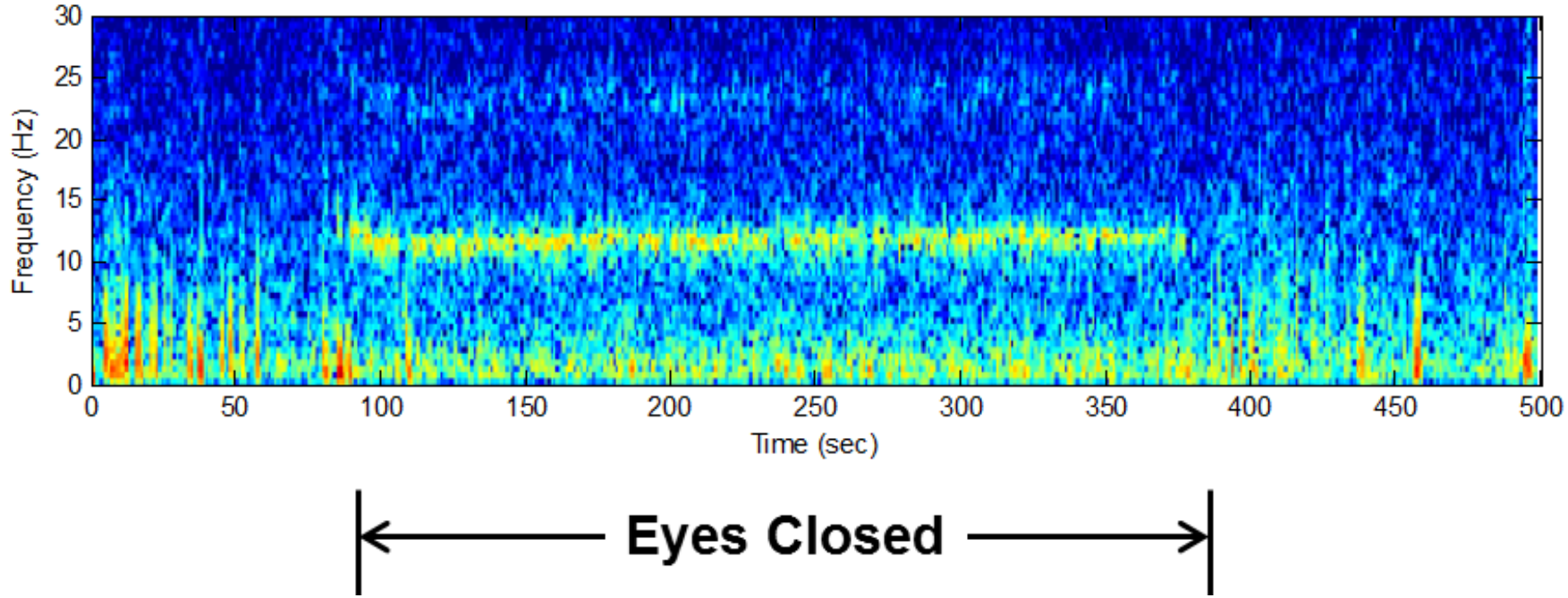
- Clearly smoothed spurious peaks and valleys
- The effect of the wide main lobe is seen (compare to the rectangular window) as smoothing (decrease of frequency resolution)

Averaged PSD using K=11 segments (Welch estimate of the PSD)

- a smooth spectral estimate with a dominant peak around 10 Hz (i.e. alpha rhythm)
- The effect of Hann window:
  - Low side lobe level: less spectral leakage i.e. reduced power levels beyond 30 Hz
  - Wide main lobe: the smoothing around 10 Hz

Spectrogram

- The frequency content of the signal over time
- Closing eyes associates with alpha rhythm in EEG
- → the frequency content of the signal clearly changes as the eyes are closed (frequency component of ~10 Hz appears)



Spectrogram

- The time signal broken up into segments
- The power spectrum density estimates are calculated for each segment
- The power spectrums of segments are displayed side by side in spectrogram

References

- The course book:
  - Chapters 1, 6 & 8