Correlation analysis of EEG and EMG

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Outline

1. Aim of the study
2. EEG and EMG signals
3. EEG-EMG processing
4. Preliminary results
5. Conclusions and future perspectives
Rationale:
Voluntary movement is controlled by the brain that sends/receives precise signals to/from muscles and nerves.

Research question:
What is the origin of involuntary movements, like *bursts*? Is that voluntary control?

Healthy EMG, background activity.
Pathological EMG with bursts.
**EEG:** frequency band 0.5-45 Hz; amplitudes of few tens of µV

**EMG:** frequency band 5-200 Hz; amplitudes in the range of mV

**EEG:** typical classification (brain rhythms).

**EMG:** origin and components.
Typical behaviours at rest:

Healthy case: amplitudes < 10 µV, frequency band 5-50 Hz.
Pathological case: amplitudes < 200 µV, frequency band 5-200 Hz.
Given $x[n]$ and $y[n]$ discrete signals, e.g. digitized EEG and EMG:

**Cross-correlation coefficient:**

$$r_{\text{max}} = \frac{\max(r_{xy}[n])}{\sqrt{E_x E_y}}$$

where $r_{xy}[n] \triangleq \sum_{m=-\infty}^{+\infty} x^*[m]y[n + m]$ is the cross-correlation function between $x[n]$ and $y[n]$.

**Delay:** $\text{lag} = \text{argmax}(r_{\text{max}})$

**Coherence (absolute value):**

$$\text{Coh}_{xy}(f) \triangleq \frac{\mathcal{P}_{xy}(f)}{\sqrt{|\mathcal{P}_x(f)|} \cdot \sqrt{|\mathcal{P}_y(f)|}}$$

where $\mathcal{P}_x(f)$ and $\mathcal{P}_y(f)$ are the power spectral density (PSD) of $x[n]$ and $y[n]$, respectively, and $\mathcal{P}_{xy}(f)$ is the cross-PSD.
Preliminary Results on Correlation

71 EEG-EMG pairs (duration 696 ± 656 ms)

Cross-correlation function maximum.  
Cross-correlation delay.
Preliminary Results on Coherence

Healthy case ($CL = 0.067$, $\alpha = 0.95$).

Pathological case ($CL = 0.451$, $\alpha = 0.95$).

with confidence level, $CL$: $CL = 1 - (1 - \alpha)^{\frac{1}{N-1}}$
Conclusions

✓ Confirmation of human physiology (maximum of cross-correlation function is about 10 ms).

✓ Healthy coherence has a peak around 20 Hz (and lower frequencies), in line with literature.

✓ Pathological coherence has a peak around 20 Hz, but also *spurious peaks* at higher frequencies (35-40 Hz).

Future Perspectives

- Enlarge the experimental samples
- Comparison with other measures to support the presence of voluntary sensorimotor control.
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