University of Zurich[UZH]
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

**Institute for Biomedical Engineering / Translational Neuromodeling Unit**

Computational Psychiatry Seminar Spring Semester 2015

# EEG Signal Processing: Theory and practice

Gabor Stefanics, Tina Wentz, and Klaas Enno Stephan

Where & when: The course takes place on Friday afternoon between 14-16h in room ETZ F 91 (ETZ building, Gloriastrasse 35) during the spring semester February-May.

To receive credit points, you must either
1) complete exercises from at least 4 chapters from Cohen 2014 (three sets of exercises from chapters 11-19, and one set from 20-34)
2) or complete a Dynamic Causal Modeling exercise using SPM.

**Week 1 (February 20): EEG Signal Processing Basics**

Presenter: Gabor Stefanics

[1] Chapters 1-9 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Jackson AF, Bolger DJ. (2014) The neurophysiological bases of EEG and EEG measurement: a review for the rest of us. Psychophysiology 51, 1061-1071.

**Week 2 (February 27): The convolution theorem, and the discrete time Fourier transform**

Presenter: Eduardo Alberto Aponte Perez

[1] Chapters 10-11 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Chapter 11 from Steven J. Luck (2014) An Introduction to the Event-Related Potential Technique. MIT Press

**Week 3 (March 6): Wavelets and wavelet convolution**

Presenter: Frederike Petzschner

[1] Chapters 12-13 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press

**Week 4 (March 13): Band-pass filtering and the Hilbert transform**

Presenter: Jakob Heinzle

[1] Chapter 14 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Chapter 12 from Steven J. Luck (2014) An Introduction to the Event-Related Potential Technique. MIT Press

**Week 5 (March 20): Short-time Fast Fourier Transformation; Multi-taper analysis; Filtering as implemented in SPM12**

Presenter: Daniel Renz

[1] Chapters 15-17 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press

**Week 6 (March 27): Time-frequency power, and baseline corrections; Inter-trial phase clustering**

Presenter: Sandra Iglesias

[1] Chapters 18-21 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Buzsaki: The 1/f Statistical Behavior of EEG (Rhythms of the brain, Oxford, pp. 119-135)

***Note: no lecture on April 3 (Good Friday)***

**Week 7 (April 10): Spatial filters 1 (Surface Laplacian, PCA, ICA)**

Presenter: Sudhir Shankar Raman

[1] Chapters 22-23 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Hyvärinen A, Oja E. (2000) Independent Component Analysis: Algorithms and Application. Neural Networks 13(4-5):411-430.

**Week 8 (April 17): Spatial filters 2 (Basics of single dipole and distributed source imaging)**

Presenter: Lars Kasper

[1] Chapter 24 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Mattout J, Henson RN, Friston KJ. (2007) Canonical source reconstruction for MEG. Comput Intell Neurosci. 2007:67613.
[3] López JD, Litvak V, Espinosa JJ, Friston K, Barnes GR. (2014) Algorithmic procedures for Bayesian MEG/EEG source reconstruction in SPM. Neuroimage 84:476-87.

**Week 9 (April 24): Connectivity 1 (Introduction to the various connectivity analyses. Phase-based and Power-based connectivity)**

Presenter: Andreea Olivia Diaconescu

[1] Chapters 25-27 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press

*Note: no lecture on May 1 (Labour Day)*

**Week 10 (May 8): Connectivity 2 (Granger prediction. Mutual information. Cross-frequency coupling. Graph theory)**

Presenter: Lilian Weber

[1] Chapters 28-31 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press

**Week 11 (May 15): Connectivity 3 (Dynamic Causal Modeling of EEG)**

Presenter: Tina Wentz

[1] David O, Friston KJ. (2003) A neural mass model for MEG/EEG: coupling and neuronal dynamics. NeuroImage 20, 1743-1755.
[2] David O, Harrison L, Friston KJ. (2005) Modelling event-related responses in the brain. Neuroimage 25, 756-770.
[3] David O, Kiebel SJ, Harrison LM, et al. (2006) Dynamic causal modeling of evoked responses in EEG and MEG. Neuroimage 30, 1255-1272.
[4] Garrido MI, Kilner JM, Kiebel SJ, Stephan KE, Friston KJ. (2007) Dynamic causal modelling of evoked potentials: a reproducibility study. Neuroimage 36, 571-580.

**Week 12 (May 22): Joint Analysis of EEG and fMRI**

Presenter: David Cole

[1] Debener S, Ullsperger M, Siegel M, Engel AK. (2006) Single-trial EEG-fMRI reveals the dynamics of cognitive function. Trends Cogn Sci. 10, 558-63.
[2] Henson RN, Flandin G, Friston KJ, Mattout J. (2010) A Parametric Empirical Bayesian framework for fMRI-constrained MEG/EEG source reconstruction. Human Brain Mapping, 31, 1512-1531.

**Week 13 (May 29): Statistical analyses (Advantages and limitations of different statistical procedures; Non-parametric permutation testing; Within-subject and group-level analyses)**

Presenter: Justin Chumbley

[1] Chapters 32-35 from Mike X Cohen (2014) Analyzing neural time series data: Theory and practice. MIT Press
[2] Chapter 10 from Steven J. Luck (2014) An Introduction to the Event-Related Potential Technique. MIT Press

"The EEG Signal Processing methods are many, varied, ever-changing, and eternal. Studying them is like fighting a many-headed monster, which, each time a neck is severed, sprouts a head even fiercer and cleverer than before. You are fighting that which is unfixed, mutating, indestructible."

—Professor Severus Snape