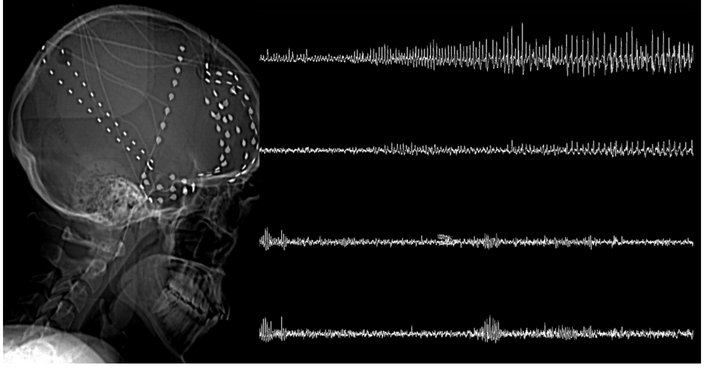

INSELSPITAL
UNIVERSITÄTSSPITAL BERN
HOPITAL UNIVERSITAIRE DE BERNE

Institute of Diagnostic and Interventional Neuroradiology

Master Thesis Proposal:

Despiking Epileptic EEG using Generative Adversarial Networks

Electroencephalography (EEG) is a key diagnostic tool in **epilepsy**. The current gold-standard is visual analysis of EEG recordings by trained experts, who look for specific grapho-elements like spike-and-wave discharges or focal slowing. Since **spikes** (i.e. highly synchronized discharges that are isolated from the background EEG) are considered an abnormal electrical phenomenon associated with epilepsy, they are of special interest in EEG analysis. However, there is conflicting evidence regarding the relationship between spiking and ictogenesis, i.e. the generation of a seizure.

To support diagnostics, in the last 20 years a variety of **quantitative EEG** (qEEG) analysis methods has been developed. They aim at revealing and quantifying signal properties that may escape expert analysis. However, it has not yet been sufficiently studied, whether qEEG measures are sensitive to phenomena that are independent or complementary to epileptic spikes. In order to approach this question, we need an algorithm to **remove spikes from EEG recordings**. Analysis of despiked EEG can then be compared to analysis of the original signals.

Jmail et al. (2017) have introduced a spike fitting algorithm that requires spike detection as a first step and makes strong assumptions about the shape of a spike. In the proposed **master thesis project** we aim at using **Generative Adversarial Networks** (GANs, Goodfellow et al. 2014) for a similar purpose. Clinical EEGs recorded at the Inselspital (~100 patients, 30-120 channels, sampling rate 512 or 1024 Hz) are available and can be used immediately. Restricting the training data to spike-free EEG, this will allow to generate artificial signals that resemble the original EEG closely in spike-free situations and continuously replaces spikes with plausible EEG-like signals (Hartmann et al. 2018). As a starting point for this GAN-based despiking strategy we will use GAN-based denoising algorithms for physiological signals (Casas et al. 2018, Gandhi et al. 2018).

The student's tasks are:

- review the literature on GANs and despiking of EEG
- devise and train a GAN
- evaluate performance using real EEG of epilepsy patients

Specific requirements:

- machine learning
- signal processing
- basic statistics
- programming skills in Python

Nature of the master thesis:

- literature study: 20%
- implementation: 30%
- testing: 30%
- documentation: 20%

Supervisor:
PD Dr. Christian Rummel (PhD)

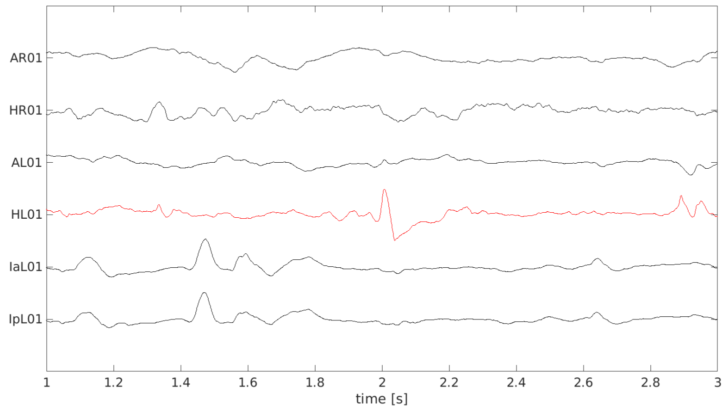

Figure: Epileptic spike on signal HL01 (red trace, appearance at t=2s), recorded from a depth electrode targeting the left hippocampus of an epilepsy patient. The other signals show normal EEG activity during spike occurrence.

References:

- Casas L, Navab N, Belagiannis V (2018). Adversarial Signal Denoising with Encoder-Decoder Networks. arXiv:1812.08555v1
- Gandhi S, Oates T, Mohsenin T, Hairston D (2018). Denoising Time Series Data Using Asymmetric Generative Adversarial Networks. D. Phung et al. (Eds.): PAKDD 2018, LNAI 10939, pp. 285–296, 2018.
- Goodfellow I et al. (2014). Generative Adversarial Networks. In: NIPS. 2014.
- Hartmann KG, Schirrmeister RT, Ball T (2018). EEG-GAN: Generative adversarial networks for electroencephalograhic (EEG) brain signals. arXiv:1806.01875v1
- Jmail N, Gavaret M, Bartolomei F, Benar CG (2017). Despiking SEEG signals reveals dynamics of gamma band preictal activity. Phyiol. Meas. 38, N42-N56.

Christian Rummel (PhD)
Support Center for Advanced Neuroimaging (SCAN)
Institute of Diagnostic and Interventional Neuroradiology
Inselspital, 3010 Bern

Tel. 0041 31 6328038
Fax 0041 31 6324872
christian.rummel@insel.ch