Master Internship/Graduation Project:
Anomaly detection in recordings of the sleeping brain

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Background:
Sleep is a vital part of a human being's day in order to keep the body in a well-functioning state and 'clean up' unnecessary memories in the brain. While not precisely understood at this moment, some definitions of 'normal' sleep may be given. When a person exhibits abnormal sleeping behavior, a polysomnography (PSG) recording may be made. Such a measurement includes (among others) electroencephalography (EEG), chin electromyography (EMG) and electrooculography (EOG) data during sleep. The American Academy of Sleep Medicine (AASM) [1] distinguishes different states through which a sleeping brain transitions during the night: rapid eye movement (REM) sleep, non-REM sleep (subdivided into N1, N2, and N3), and wakefulness. Given a PSG recording, a sleep expert labels each window of 30 seconds with one of the five possible states to create a hypnogram; a visual representation of assigned sleep stages over the full night. Diagnosis for many sleep disorders is subsequently made by looking for specific patterns in the signals and/or inspecting the sleep structure, as visualized in the hypnogram.

Problem description:
Some sleep disorders exhibit clear symptoms, while objective measures in the recordings are absent or do not fully explain the visible symptoms. An example is the non-REM parasomnia disorder, which can be subdivided into several sub-disorders of which sleep walking is a well-known example. People that are diagnosed with sleep walking do show an increased number of sudden transitions from deep sleep N3 to Wakefulness, as compared to healthy sleepers. While some of these N3-W transitions are followed by behavioral events (e.g. speaking, walking etc.), others are not. So far it has not been understood which patterns in the data are causes or consequences of these behavioral events in this group of patients.

Methods:
The goal of this project is to design an anomaly detection (machine learning) model that detects patterns in data that are abnormal with respect to what the model has seen before. Training such a model on data from health-sleepers enables detection of abnormal patterns that are absent in healthy sleepers, but present in the recordings of patients with sleep disorders.

The project will be divided into two parts. First, a recently-proposed anomaly detection model [2], based on Contrastive Predictive Coding [3] will be translated and adjusted for use on PSG recordings. Second, the model will be evaluated on data from non-REM parasomnia patients in order to see where abnormal patterns can be found.

Requirements:
- Knowledge in deep learning, for example from course 5LSL0 (or similar courses).
- Python
- Experience in Pytorch (or Tensorflow)

Duration: This project can be done as 3-month internship or a full graduation project. Though, for an internship, having already high proficiency in python and Pytorch programming is essential in order to be able to work on phase 2 as well.

References:
[1] R. B. Berry, R. Brooks, C. E. Gamaldo, S. M. Harding, C. Marcus, B. V. Vaughn et al., "The AASM manual for the scoring of sleep and associated events," Rules, Terminology and Technical Specifications, Darien, Illinois, American Academy of Sleep Medicine, vol. 176, p. 2012.

[2] de Vries, I. R., Huijben, I. A., Kok, R. D., van Sloun, R. J., & Vullings, R. (2022, May). Contrastive Predictive Coding for Anomaly Detection of Fetal Health from the Cardiotocogram. In *ICASSP 2022-2022 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)* (pp. 3473-3477). IEEE.

[3] Oord, A. V. D., Li, Y., & Vinyals, O. (2018). Representation learning with contrastive predictive coding. *arXiv preprint arXiv:1807.03748*.