Master Internship/Graduation Project:
Automatic sleep staging on noisy data streams

Contact: Iris Huijben (i.a.m.huijben@tue.nl)

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. To measure someone's sleep, a polysomnography (PSG) recording is used. 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. This manual labelling process is time-consuming, and experts are only trained to score 30-sec windows of recordings made with the exact sensor (positions) as indicated in the AASM guidelines.

Problem description:
The conventional PSG measurement is problematic since it brings discomfort to the patient during sleep and therefore may interfere with the natural sleep process of the subject. This discomfort arises due to the measurement being done in a clinical setting (sleeping in a different bed), the large number of sensors attached to the body, and the connection to a back-end device via wires, which hampers free movement during sleep. Onera Health, located in Eindhoven, is a company that is developing a device to measure EEG, EOG, chin EMG, ECG etc. via wireless patches to be used in the home setting. The promise of this device is to alleviate the interference in the sleep process. Thanks to the possibility to measure at home, patients can be measured for multiple nights. However, this raises challenges for sleep staging, as manually labelling all nights is very time-consuming. Therefore, an automatic sleep staging algorithm is desirable. Due to the different nature of the sensors (and its positions) compared to the conventional PSG, the recordings may differ and existing sleep staging algorithms might need adjustments. Also, quality of the signals might (temporarily and locally) drop due to the patch getting dis-attached as a consequence of movement. The algorithm should thus also be able to detect these events and deal with it appropriately. Lastly, our measurements are known to exhibit cross-inference across channels, which we might want to filter out.

Methods:
The goal of this project is to design an automatic sleep staging model that predicts sleep stages, given noisy and temporarily faulty recordings. The project can be subdivided into several sub-questions. First, how to deal with partly missing data channels? For this problem, inspiration can be taken from a recent work on EEG data [2]. Second, how to deal with the cross-interference between channels? To solve this, we might use (a combination of) adaptive filtering and/or a machine learning models to filter out the interferences.

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 speed up the start-up phase.

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] Banville, H., Wood, S. U., Aimone, C., Engemann, D. A., & Gramfort, A. (2022). Robust learning from corrupted EEG with dynamic spatial filtering. *NeuroImage*, *251*, 118994.