An upcoming Study: Semi-Supervised Learning in EEG-Based Epileptiform Pattern Detection

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Introduction

Electroencephalography (EEG) is a standard tool to record and monitor epileptic seizures, and is usually performed at the hospital. HypoSafe A/S is developing a small and wearable EEG-measuring device for everyday use that can record continuous two-channel EEG for months, see Figure 1. Monitoring the EEG of an epilepsy patient can lead to new insight into a patient's seizure patterns, but it requires identification of the periods of the EEG containing epileptiform discharges. Identification of such patterns in the EEG by visual inspection is highly time consuming and labor intensive, which creates the need for an automatic seizure detection method.

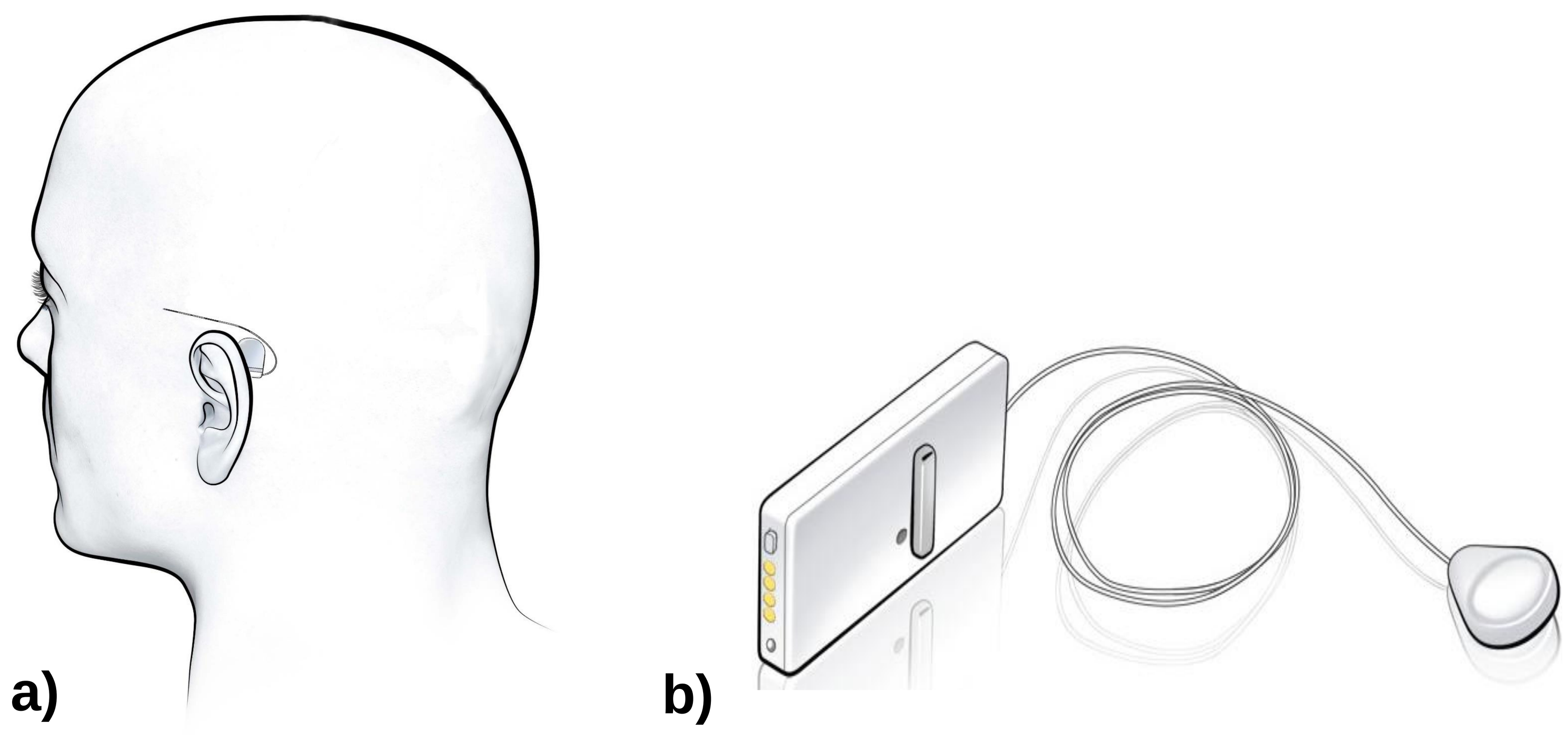

***Figure 1:** HypoSafe's EEG monitor consists of two parts, an implantable part (a) with three electrodes, and an external device (b) that receives and stores the EEG signal from the implant. The communication between the implant and the external device happens via an inductive link through the skin.*

Data

Data will be collected in a clinical study with 20-40 temporal lobe epilepsy patients wearing the new EEG monitoring device. Each patient will be monitored for approximately 4 months. EEG recordings of this length is unprecedented in the epilepsy community. The data are recorded in two channels with a sampling frequency of 207 Hz, and band pass filtered between 0.5 and 30 Hz. An example of an EEG recording from a previous clinical trial can be seen in Figure 2.

Method

The method will comprise four stages, see Figure 3. **Stage 1:** A neurophysiologists will label a small portion of the data set for each patient. **Stage 2:**Based on these labels, a semi-supervised algorithm will identify potential epileptic EEG segments in the rest of the data set. The algorithm in this stage will have high sensitivity, but low specificity. **Stage 3:** The neurophysiologist will evaluate the possible epileptic EEG segments from Stage 2 to identify True Positives (thereby creating a large labelled data set). **Stage 4:** From this new data set, a fully supervised, patient specific detection algorithm will be designed, with high sensitivity and positive predictive value.

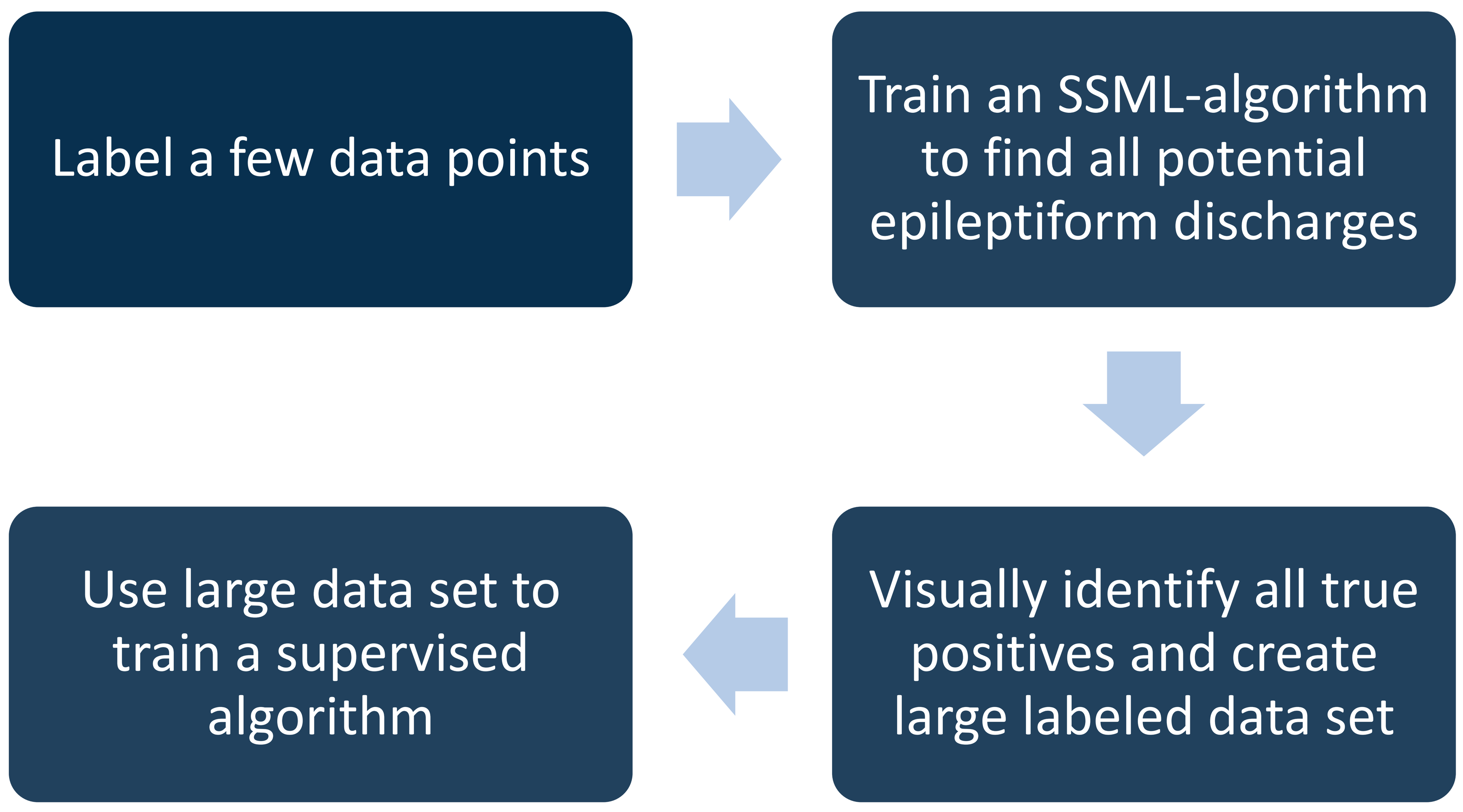

***Figure 3:** The four stages of the method designed to identify epileptiform discharges in ultra-long EEG recordings.*

Anticipated Challenges

Highly imbalanced data set
The expected amount of ictal and inter-ictal epileptiform activity recorded during the four months is on the timescale of minutes. The amount of normal EEG is therefore *much* larger.

Overlapping class distributions
Several other physiological processes generate signal patterns that are similar to epileptiform patterns, and may also be more prevalent.

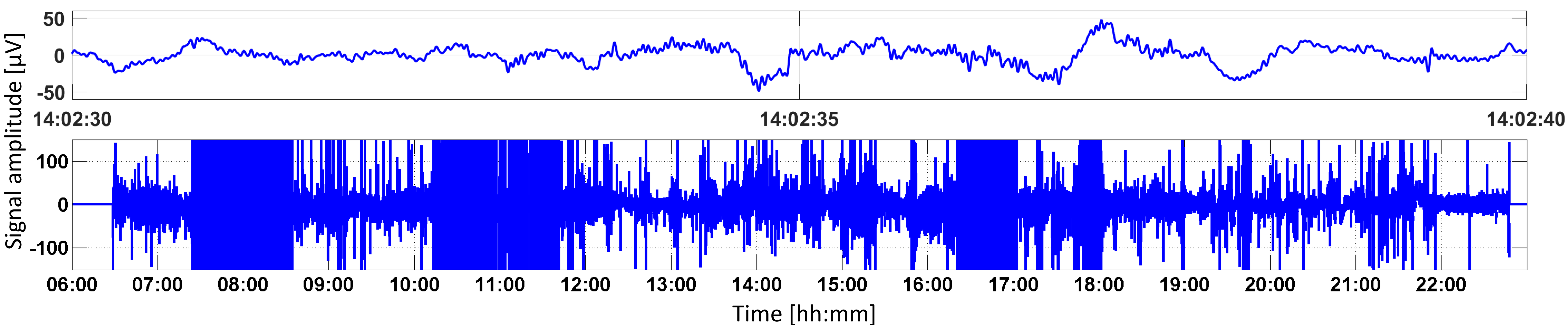

***Figure 2:** An example of an EEG recording from a healthy subject from a previous trial. The top panel shows a 10 second segment taken from the full-day recording seen in the bottom panel. For simplicity, only one of the two channels is plotted here.*