Automatic detection of sleep episodes in long-term EEG recordings

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WearMeSoC RTD 2013

Introduction

Multiple sleep latency tests (MSLT) are standard tools in the diagnosis of hypersomnia and narcolepsy. Such tests require a huge effort, and therefore are expensive. We aimed to explore the possibility of performing long-term recordings in patients with portable devices and subsequent automatic analysis. Such recordings could be performed in the patient's habitual environment. Thus, we aim to develop algorithms for the automatic detection of sleep onset in MSLT.

Methods

Polysomnographic (PSG) recordings were obtained in patients with hypersomnia and narcolepsy who underwent a multiple sleep latency test (MSLT). Sleep (30-s epochs) was visually scored by an expert based on standard criteria. We calculated spectrograms of derivation C3A2 using Welch's power spectral density estimate (average of six 5-s epochs, Hanning window). We extracted power of various frequency bands, parameters of corresponding autoregressive model and other features, including eye movements and muscle tone (EMG) resulting in a total of 43 features. For classification we used the random forest algorithm (250 trees). The algorithm was trained on two recordings and tested on further two recordings.

Results

With the above-mentioned approach, we were able to reliably differentiate sleep and wakefulness. Additionally, we were able to dissociate non-REM sleep stages 1 and 2 as well as REM sleep. We observed some difficulties to separate REM and stage 1 sleep by the algorithm. However, stage 2 sleep was reliably identified. An example of automatic scoring compared with an expert scoring is illustrated in Figure1.

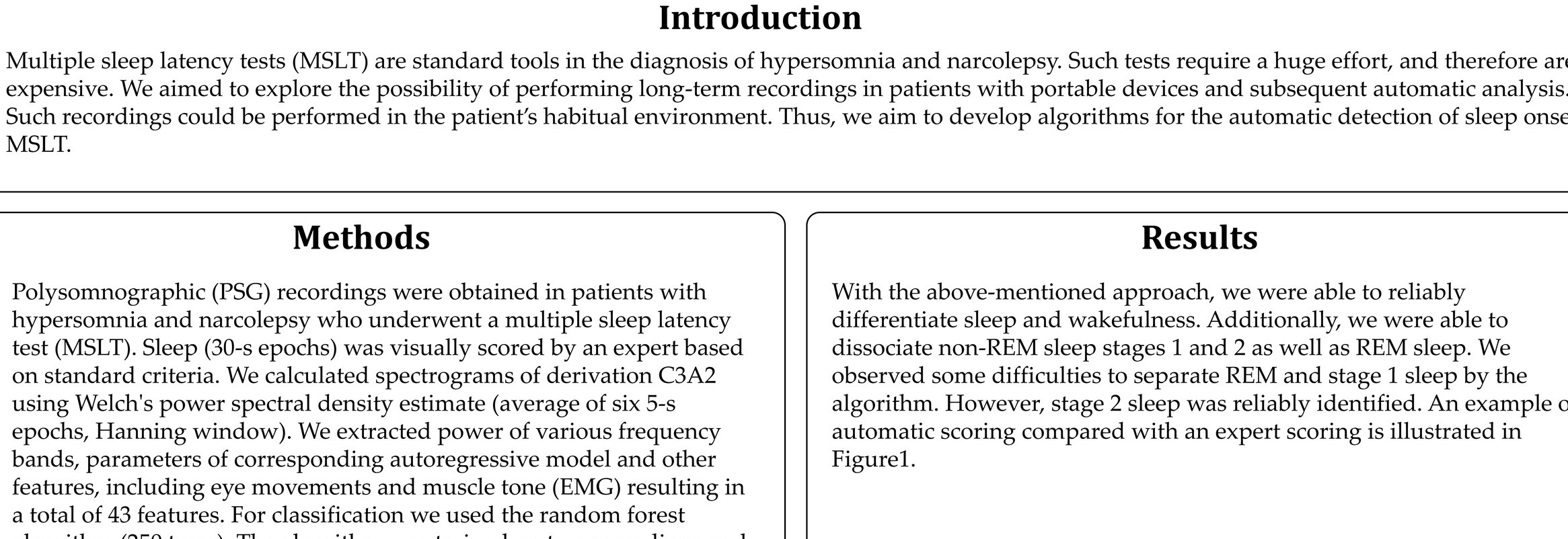

Figure 1. *Top: Visual scoring (30-s epochs) of sleep (first sleep opportunity in MSLT) by an expert. Middle: Automatic scoring by the algorithm. Bottom: Spectrogram. Yellow indicates lights on. W: waking; R: REM sleep; 1 to 3: non-REM sleep stages 1 to 3. On the left panel you can see the data of a patient with narcolepsy and on the right panel the data of a patient with hypersomnia.*

Conclusions

We demonstrated that it is possible to detect sleep onset in continuous long-term polysomnographic recordings using simple quantitative measures. Dissociation of stage 1 and REM sleep is often also difficult for human scorers. However, we think that the algorithm can be further improved. Reliable identification of REM sleep is important in particular for the diagnosis of narcolepsy. In future, we are going to improve the classification by taking into account the temporal structure of the data.