Sleep-Wake Classification for Home Monitoring of Sleep Apnea Patients

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Background: As there exists an evolution towards home-based screening and monitoring of patients, essential information needs to be derived from unobtrusive sensors. Many sleep disorders require information of the patient's sleep stages. One of these is sleep apnea, where the total sleep time is essential to assess the disorder severity. Therefore, a sleep-wake classifier was developed based on heart rate and respiration, allowing the application of different sensor types. This classifier was applied to unobtrusive capacitive-coupled ECG (ccECG) data acquired from a mattress-integrated sensor.

Methods: A 1D convolutional neural network (CNN) was designed to classify 30s epochs of ECG-derived tachograms and respiratory inductance plethysmography (RIP) signals. A dataset of 56 patients with apnea-hypopnea index (AHI) below 10 was used to train and validate the network. The CNN was applied to an independent test set of ECG and RIP signals of 25 subjects (dataset 1). Of these, 16 subjects with AHI<10 were simultaneously monitored using ccECG. Only epochs with sufficiently good quality ccECG were retained, although these could still contain artefacts. Outliers in the extracted tachograms were either corrected or removed. A subset of five subjects met the requirement of retaining at least 15 wake epochs (dataset 2). The Cohen's Kappa score assessed performance over different subjects.

Results and Conclusions: The results are displayed in Table 1. The performance on independent dataset 1 is comparable to literature. The tachogram-based input allows other sensor types as well. However, application on dataset 2 results in a drop in performance. This is partially due to a low amount of wake epochs and the correction for outliers in the ccECG-derived tachogram on the other hand. Different artefact-handling techniques should be investigated to assess the effect on ccECG-based sleep-wake classification performance. An extended ccECG data collection is expected for further development and validation.

Table 1 Classification performance on independent test sets

Dataset	# subj	AHI	# epochs	% wake	Kappa mean ± std	Kappa max
(1) ECG + RIP	25	4.7 ± 2.5	26 458	14.7	0.51 ± 0.13	0.74
(2) ccECG + RIP	5	4.7 ± 3.3	2616	11.4	0.29 ± 0.17	0.54