Short-term prediction versus detection of microsleep events

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Maintaining attention under conditions of monotony, mental underload, and sleep pressure is critical for safe driving, especially during long distance highway rides. Despite deficient reactions and fluctuations in lane tracking performance, these conditions may result in unexpected, short attention lapses, so-called microsleep (MS) events. They are accurately detectable if short-term EEG processing and subsequent machine learning is utilized [1, 2]. It is asked if they are also predictable, i.e. if there are specific EEG patterns immediately before their occurrence.

EEG was recorded during overnight driving simulations in the lab. Each of 16 participants completed 7 driving sessions of 40 min duration each, between 1:00 AM and 7:40 AM. Visual observation of driver's behaviour by trained experts yielded 1,484 examples of MS events. In addition, 1,940 counterexamples of sustained attention (SA) were included for further analysis. Immediately before each MSE and each SA example, 8 sec long EEG segments were analyzed by the modified periodogram and in accordance to [3] by Choi-Williams distribution. For each segment, periodogram resulted in 161 signal features over all 7 channels (Fp1, Fp2, C3, Cz, C4, O1, O2). The second method resulted in 648 features over all 7 channels and over 6 ipsilateral and 5 contralateral channel pairs, in accordance to [3]. Support-vector machines (SVM) with Gaussian kernel function were empirically optimized in order to map signal features to the event type (MS or SA).

Processing periodogram features yielded mean classification accuracies of 98.9±0.05% and 87.5±0.1% for training and test data, respectively. Processing Choi-Williams distribution features yielded mean classification accuracies of 97.3±0.07% and 82.7±0.1% for training and test data, respectively.

In conclusion, the prediction of behavioral MS events is less accurate by approximately -10% compared to the detection case [4], where EEG segments contain pattern of ongoing MS events. Results support the hypothesis that MS events are triggered by subcortical processes and happen involuntarily. This is important for forensic considerations of MS events and the difficulties of the driver to be aware of upcoming MS events. Another conclusion concerns the time-frequency analysis performed by Choi-Williams distribution which did not improve results of spectral analysis performed by the periodogram method.

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