Towards the detection of microsleep events in a driving simulator

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Abstract

In this paper we describe our experimental setup that we use for the analysis of driver fatigue and microsleep events. The driving simulator is based on an SGI Visual Workstation and equipped with a car seat, a force feedback steering wheel, pedals and a large back projection screen for a realistic driving simulation. The back projection screen offers a field of view of up to 60°. We collect two different kinds of data based on multichannel EEG and the tracking of gaze and eye lids (blink). Gaze and blink data are obtained from a commercial video-based system (InSight, SensoMotoric Instruments, Berlin, Germany). We then perform a multivariate data analysis of the two synchronized data streams. The data are collected during overnight driving sessions of volunteers in our lab. To obtain a sufficient number of microsleep events, each subject has to drive on a simulated straight highway for three hours. The multivariate data analysis is then performed in two steps: (i) feature extraction and (ii) classification. Preliminary results will be presented at the conference.

Keywords: microsleep detection, EEG, eye-tracking, classification, driver monitoring

1. Motivation

Driver fatigue is, with an estimated incident rate of 15-20%, one of the most frequent causes of heavy traffic accidents, outnumbering the high rate of car accidents under the influence of drugs or alcohol. Therefore there is an ongoing academic and technical quest to find ways to identify fatigue-related events such as:

- clear lack of awareness,
- sudden drowsiness,
- microsleep.

Our working assumption is that such events will correlate with observable physiological and behavioural states of the driver and can therefore be detected by appropriate measurements.

2. Physiological and behavioural correlates of fatigue and sleep

In the EEG signal, microsleep events are expected to cause brief runs of theta or delta activities that last several seconds while beta and alpha-type EEG activity would be indicative of alertness. The video system's blink measurement will be used to determine the duration of eye closure (PerClose) and the speed of eye-lid opening [4] since both features are known to correlate with the state of fatigue. In addition, (spontaneous) oscillations in pupil width will be considered. Hopefully, the physiological and behavioural indicators of fatigue will be well correlated such that decisions can be made based on only the unobtrusive video system.

3. Methodology

The neurological definition of microsleep events treats these events as a spontaneous and irregular change from one sleep stage to another, allowing us to use methods and algorithms normally used in sleep stage classification.

To estimate the sleepiness and to classify microsleep events we construct feature vectors and label them according to the corresponding sleep stage and our definition of microsleep. These vectors are then used to train the high-speed classifier (ALN [7]) built into our custom data acquisition software. During training, each feature component is weighted according to its significance. Thus, we also obtain feedback about the correlation between EEG and Eye tracking features. To improve generalization (adaptive) bagging [9] is used.

In order to provide a realistic measurement setup, we have built a simple car simulator that can simulate monotonous motorway rides. The simulator is equipped with multichannel electrophysiological recording systems, video cameras and a high speed gaze and blink tracker. To successfully detect microsleep events, we perform multivariate data analysis of two synchronized data streams: multichannel (32 channels) DC-EEG (NeuroPRAX [8]) and signals originating from the eye-tracking device (InSight [6]). The data is collected from overnight driving sessions of volunteer subjects in our lab. To gain a useful number of microsleep events, each subject has to drive for three hours on a simulated highway at night time. The multivariate data analysis is then performed in two steps: first, feature extraction which is then followed by classification. For performing the classification, we are using a high speed classifier (ALN, DLE [7]) that has demonstrated to perform well in noisy situations in the past. The recordings are gathered in a dark, quiet lab under controlled conditions.

Car simulator (EEG not shown)

InSight system (courtesy SMI)

In order to assure results that apply to real life situations, certain preconditions have to be met. Each subject has to fill out a questionnaire to demonstrate a medical history devoid of relevant pathological findings e.g. no suffering from insomnia. Taking of analeptics like caffeine is also forbidden. To get additional feedback about the subject's alertness, each subject has to determine his/her level on the Stanford sleepiness scale to provide some additional feedback about the subjective state of fatigue.

4. Conclusion

We have described our experimental setup for measuring EEG signals and behavioural data under simulated driving conditions. We have also shown how we plan to correlate the two different data streams and build a detector for fatigue and microsleep. Preliminary results will be shown at the conference.

5. Literature

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