Short description:

Drowsiness is an intermediate condition between alertness and sleep which reduces the consciousness level and hinders a person to respond quickly (Awais, Badruddin, & Drieberg, 2017). According to the report of the National Highway Traffic Safety Administration (NHTSA) (National Center for Statistics and Analysis, 2017) drowsiness contributes to about 83,000 traffic accidents and 900 fatalities each year in the USA. Drowsy driving has caused about 2.5 percent of fatal accidents from 2011 through 2015 in the USA and it is estimated to produce an economic loss of USD 230 billion annually (Correa, Orosco, & Laciar, 2014) . Klauer et al. have found in their study that drowsiness in drivers contributed to 22%-24% of the crashes or near-crashes risks. The German Road Council (DVR) has also reported that one out of four fatal highway crashes has been caused by drowsy drivers (Husar, 2010). Drowsiness detection systems are intended to warn the drivers before an upcoming level of drowsiness gets critical, in order to prevent drowsiness-related accidents.

Accurate and reliable detection of drivers' drowsiness is significantly important to prevent drowsiness-related accidents. In order to design a non-obtrusive drowsiness detection system, vehicle-based measures play a vital role. The attached manuscript, presents a novel method based on deep neural networks for drowsiness detection in drivers using vehicle-based measures. The proposed method is based on a combination of convolutional neural networks (CNN) and recurrent neural networks (RNN). Five vehicle-based measures including lateral deviation from road centerline, lateral acceleration, yaw rate, steering wheel angle and steering wheel velocity are exploited as network inputs. Long-short term memory (LSTM) and gated recurrent unit (GRU) layers are used as RNN in the structure of the designed deep network. The level of drowsiness is classified in three different classes including awake, moderately drowsy and extremely drowsy. The performance of the proposed method is evaluated on experimental data that were collected from 20 driving sessions in a fixed-base driving simulator. Results show that the designed deep networks outperform the classification accuracy of classical classifiers like support vector machine and k-nearest neighbors. Combination of CNN and LSTM (CNN-LSTM) shows the highest accuracy for detection of these three classes which is equal to 96.0%.

This paper is the first one to present results of the WACHsens study and already has been submitted for the journal of Expert System with Applications (https://www.journals.elsevier.com/expert-systems-with-applications). Its aim is the multi-level classification of driver drowsiness using vehicle-based data. Three different drowsiness levels have been considered: alert, moderately drowsy and extremely drowsy. The study took place in a fixed-base driving simulator (Advanced Driving Simulator of Graz, ADSG) at the Graz University of Technology (TU Graz) which is based on an altered production vehicle, see Fig. 1. In this study, manual-tired tests from 22 persons (13 women, 9 men; mean age 45 years +/- 17 SD, age range 22 to 71 years) that were selected which include the full range of transition from alert to extremely drowsy have been considered to classify different levels of drowsiness.

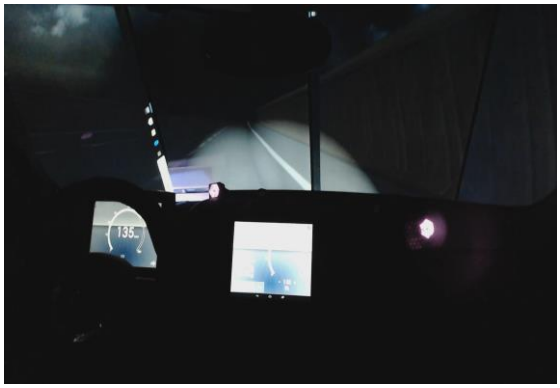

Fig. 1. The Advance Driving Simulator of Graz (ADSG) is a modified production car, here pictured without the external housing that separates the whole simulator from the environment during the tests (left). The test track from driver's view simulated a night drive on a highway (right).

References:

Awais, M., Badruddin, N., & Drieberg, M. (2017). A hybrid approach to detect driver drowsiness utilizing physiological signals to improve system performance and wearability. *Sensors, 17*(9). doi:10.3390/s17091991

Correa, A. G., Orosco, L., & Laciar, E. (2014). Automatic detection of drowsiness in EEG records based on multimodal analysis. *Med. Eng. Phys., 36*(2), 244-249. doi:10.1016/j.medengphy.2013.07.011

Husar, P. (2010, October 12). Retrieved from Eye tracker warns against Momentary Driver Drowsiness: https://www.fraunhofer.de/en/press/research-news/2010/10/eye-tracker-driver-drowsiness.html

National Center for Statistics and Analysis. (2017). *Drowsy Driving 2015.* Washington: National Highway Traffic Safety Administration.