Predicting when driver's state is going to become degraded

C. Jacobé de Naurois[1,2], A. Stratulat[2], C. Bourdin[1] and J.C. Vercher[1]

1 Institut des Sciences du Mouvement Etienne-Jules Marey, Aix-Marseille Université et CNRS, UMR 7287
2 Groupe PSA, Centre Technique de Vélizy, Vélizy-Villacoublay Cedex, France

Author email: charlotte.jacobe-de-naurois@univ-amu.fr

Keywords: degraded state; drowsiness; prediction; machine learning

When driving, the state of the driver, and thus his/her performance, may change over time, depending on several factors. When the driver becomes drowsy or distracted, his/her state is considered as degraded and recommendations are usually to stop driving and rest. How to detect drowsiness, distraction, stress, cognitive workload etc. is a challenge which has been extensively addressed (Dong, Hu, Uchimura, & Murayama, 2011; Ranney, 2008). Nonetheless, when the driver is sleepy or distracted, it may be already too late. The present study focuses on the temporal prediction of decreased alertness, more specifically, finding when the degraded state is going to come. An experiment was conducted on a static driving simulator. Twenty one participants drove for 120 minutes under conditions optimized to induce drowsiness. Traffic and road type varied during the experiment in order to bring different drowsiness state (Larue, Rakotonirainy, & Pettitt, 2011). During the experiment, physiological and behavioural measurements were recorded which were selected according to the literature as good indicators of driver's state (Dong et al., 2011) such as the heart rate and variability, respiration rate, head and eyelids movements (blinking duration, frequency and perclos) and driving behaviour such as time-to-lane-crossing, speed, steering wheel angle, position on the lane. Data fusion of various features was used in order to be more robust (Samiee, Azadi, Kazemi, Nahvi, & Eichberger, 2014). The real state of the driver, namely the ground truth, was defined from video recording using the Trained Observer Rating (Wierwille & Ellsworth, 1994), which consists of classifying the driver state on a scale from 0 (alert) to 4 (very sleepy) every minute. An innovative model using artificial neural network was developed in order to predict every minute, in how much time the degraded state (moderately drowsy) is supposed to happen based on recorded measurements history. A feedforward neural network with one hidden layer has been used in order to fit an input-output relationship. For 80% of the validation and testing data, the absolute value of the error between the time to predict and the time predicted by the model is less than 6 minutes. The correlation coefficient R between the time to predict and the time predicted by the model is higher than 0.75. This study shows that with a controlled and very monotonous environment favourable to drowsiness in a driving simulator, it is possible to predict the dynamics of the occurrence of a degraded state of driver. Additional studies will be carried out under real conditions and/or in different vehicle automation levels (dynamic simulator).

Dong, Y., Hu, Z., Uchimura, K., & Murayama, N. (2011). Driver inattention monitoring system for intelligent vehicles: A review. Intelligent Transportation Systems, IEEE Transactions on, 12(2), 596–614.

Larue, G. S., Rakotonirainy, A., & Pettitt, A. N. (2011). Driving performance impairments due to hypovigilance on monotonous roads. Accident Analysis & Prevention, 43(6), 2037–2046.

Ranney, T. A. (2008). Driver Distraction: A Review of the Current State-of-Knowledge.

Samiee, S., Azadi, S., Kazemi, R., Nahvi, A., & Eichberger, A. (2014). Data Fusion to Develop a Driver Drowsiness Detection System with Robustness to Signal Loss. Sensors (14248220), 14(9), 17832.

Wierwille, W. W., & Ellsworth, L. A. (1994). Evaluation of driver drowsiness by trained raters. Accident Analysis & Prevention, 26(5), 571‑581. http://doi.org/10.1016/0001-4575(94)90019-1