# Measuring driver fatigue based on eyelid opening level

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Already in 2003 (Hargutt, 2003), a method was developed that assesses driver fatigue based on eyelid opening level. The original algorithm evaluates driver state using eyelid-opening level measured based on induction between two copper coils attached to the upper and lower eyelid. The algorithm categorizes every blink in one out of four categories covering the range between alert and extremely fatigued. Since that time, the method was used successfully to assess driver fatigue for a variety of research questions on driver state (e.g. disease, alcohol, drugs, assistance systems).

Recently, the development of functions for highly automated or autonomous driving brought new spotlight onto online assessment of driver state e.g. fatigue. Because measures based on driving behaviour (like in existing driver fatigue detection systems) cannot be used in highly automated driving, measures based on direct observation of the driver (e.g. through a camera system) are needed. However, to be able to assess unobtrusively driver fatigue in the car, our existing algorithm needs to be independent from the previously used copper coils, e.g. by using data provided by a camera-based eye-tracking system.

Data from an experiment in the driving simulator will be presented that was used to transfer the original algorithm to signals provide by a camera system. N=30 drivers drove in the driving simulator for 2.5 hours on an empty highway with night-time simulation. Eyelid opening level was measured with SmartEye Pro. For reference, driver state was assessed with a variety of different measurement approaches (online expert rating and driver rating using Karolinska Sleepiness Scale (KSS), online annotation of symptoms for fatigue, driving performance). To validate the adapted algorithm, repeated KSS ratings are used as ground truth for driver fatigue because it is the only measure that covers the full range between awake and asleep and is based on a subjective combination of different symptoms of fatigue. Overall, results indicate that the algorithm differentiates successfully different levels of driver fatigue using signals from the remote eye-tracking system only. The relations between the algorithm and other measures of fatigue as well as still existing limitations of the camera based assessment and their implications will be discussed.