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Multi-Sensor Vigilance Detection: Sensor Reliability and Comfort in Automated Train Operations

Esther Bosch, David Schackmann, Stephanie Hoyer, Wolfgang Kilian, Stefan Schwanitz, Anneke Hamann

The increasing levels of automation in rail transport, such as Grade of Automation Level 2 (GOA2), introduce new challenges for train driver vigilance. Despite several operational advantages of partial automation, human operators are required to maintain a high level of attention to ensure safe operations. Prolonged monitoring tasks can lead to mental fatigue and reduced vigilance, increasing the risk of errors. One potential solution to this issue lies in multi-sensor systems that can monitor the driver's physiological state and detect signs of low vigilance in real time. The HMI4Rail project addresses this challenge by investigating the reliability and feasibility of various sensor types for detecting low vigilance in train drivers.

To explore this, a study was conducted using a high-fidelity train simulator with 14 professional train drivers. Each driver completed three simulator drive sessions with the train driving fully automated. All drives required no train operation besides activation of the dead man's button. In the second drive, a mental fatigue induction task was administered. This task involved a 55-minute n-back task with four varying difficulty levels, designed to induce mental workload and simulate the mental fatigue experienced during prolonged real-world train driving.

Throughout the study, several body-worn sensors were employed to measure physiological signals associated with mental fatigue. These included an electrocardiogram (ECG) to track heart activity, a 26-channel wet electroencephalogram (EEG) to monitor brain waves, a breathing belt to measure respiration, eye-tracking glasses to measure blink rates, and skin conductance sensors to capture changes in sweat production, a known indicator of stress and arousal. Each of these sensors was selected based on previous research demonstrating their efficacy in detecting changes in mental state, particularly under conditions of mental fatigue.

In this talk, we will present the initial findings from our study, focusing on the comparison of sensor measurements between the baseline and post-intervention simulator drives. These results will provide insights into how the drivers' physiological states changed after the mental fatigue-inducing task, offering key information on the reliability of each sensor type for monitoring vigilance in real-world applications. Additionally, we will discuss feedback from the participants regarding the comfort and practicality of wearing these sensors during their driving tasks. The wearability and comfort of these sensors are crucial factors in their potential integration into smart garments for train drivers. Our findings will inform future developments in smart garments for train drivers, with the goal of enhancing safety in automated rail systems by providing real-time monitoring of driver vigilance. By identifying the most reliable sensors and addressing comfort concerns, the HMI4Rail project takes an important step towards implementing wearable technology that supports the performance of train operators in increasingly automated environments. In a next step, the same sensor system will be tested during a real-world automated drive.