System Analysis on Driver Monitoring System for Mainline Railway

Niki Mok

TÜV Rheinland UK Ltd

Extended Abstract *Driver alertness and attention are factors in nearly 50% of Signal Passed At Danger (SPAD) events that could lead to railway accidents. Due to their shift work nature, train drivers need to overcome drowsiness and being distracted during operation. More than half of UK train drivers uses caffeine drinks, or even tablets to deal with fatigue. To ensure drivers are fit to work, the current Driver Safety Device (DSD) has been used in UK railway for decades. A DSD requires periodic pressure applied on a Deadman's pedal, handle or button for the vigilance system to reset. However, the current system can lead to routine action, or even be tricked or isolated. The delay time is 60s with action time typically 5-7 seconds that allows the driver to react and reset, or else an emergency brake applies. The timeout is much longer compared to the required reaction time for drivers to acknowledge other controls such as a train protection equipment. Moreover, a train runs hundreds of metres just within a few seconds nowadays, compared to a few decades ago when high-speed trains had not been introduced.*

Based on the multitude of problems that the current system possesses; the aim of this presentation is to introduce a system analysis to increase the capability of the existing vigilance system for UK mainline passenger trains to provide functionalities on detection and actuation based on driver's attentiveness.

This research looks at previous studies and different sensing and actuating technologies. Using Capability Systems Engineering approach, the purpose and understanding of stakeholder's needs is identified, high level performance requirements are established, and an operational concept that enables the capability of the vigilance system to be enhanced in a way that satisfies the requirements is developed.

An operational concept is proposed for a driver monitoring system with enhanced capability. A camera-based sensor emits infrared light that is able to capture images in dark environments and can accommodate drivers wearing sunglasses.

When a driver experiences drowsiness including increase in eye closure speed to above 0.5s or an increase in percentage of eye closure over time to more than 30%, a fatigue event is triggered. A sensor also detects the driver looking away for more than 1.8s as a distraction event. These occurrences are perceived by a processing unit fitted on the driving cab which activates to produce either an audio warning or seat vibration to alert the driver. Triggered by consecutive fatigue events, a message is sent to the control centre. A staff member then verifies the situation to eliminate any false-positives. The monitoring team seek action through mutual verbal agreement with the driver on whether driving operation should be continued.

This new capability is efficient in reducing the reaction time of detection on driver's falling asleep by 97% from 65s to 2s for drivers who cannot be woken by audio alarm, and by 93% for drivers from 30s to 2s who can be woken up by a beeping sound.

Additional functionalities of the proposed design include detecting early signs of falling asleep, microsleep and eyes-off-road, both intentional and unintentionally. For drivers who become incapacitated or die, the reaction time remains at 65s with no improvement in those cases which still need to rely on traditional DSD.

The new monitoring system is suggested to be deployed alongside the existing vigilance system. It does not need to interface with safety-critical functions such as the braking control circuit to support automatic emergency brake function if run in parallel with the old system. No interface issues are identified regarding ringing of both the old and new audio alarm that could potentially lead to confusion.

This research conducted for the vigilance device reflected the criticality of demand for the enhanced functionalities because of the inherent shortcomings of the traditional system. These improvements can be achieved by monitoring eyes and head movement of drivers using the re-designed capability. If implemented successfully, this new vigilance system can reduce up to 22.9% of overall fatal train accidents in UK under general assumptions.

Implementation of such a monitoring system still faces many challenges in the wider UK railway context. Concerns over data privacy need to be addressed via a robust and secure software model, and detailed negotiations with representatives from driver unions are needed to assure drivers that the system is not for surveillance purpose, nor performance judgement by the employer.

Fatigue prediction technologies available nowadays are largely based on research and development in the road driving sector. Railway operation is different in which its working environment and safety regulations are more complex. It is therefore recommended that future work should involve both a psychologist and software engineer to integrate expertise for such a monitoring system. Once the requirements are refined as the system evolves, the product will become more sophisticated on meeting both functional and non-functional requirements.

When staged implementation is completed with defects resolved, the goal is to establish a continuous improvement programme through identifying 'near misses' of fatigue and distraction events, not only to raise awareness of employees of their own fatigue level, but to strategically plan fatigue management and shift schedules more effectively. This system analysis allows the railway undertakings to understand the technical concerns and requirements associated with the usage of such a monitoring system within the railway context and give the train operating companies (TOCs) an option to explore train services that they can provide to be even safer and more reliable.