A Review of Real-Time Safety Intervention Technologies

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ABSTRACT

Real-time interventions are in-vehicle systems which are triggered while travelling, when specific conditions occur and intend to maintain and increase the safety and comfort level of the driver. This paper aims at reviewing the existing technologies utilized for real-time interventions and driver feedback in order to assist in the i-DREAMS[1] platform development. The results indicated that real-time interventions usually take the form of in-vehicle audio, visual or haptic warnings and are delivered via embedded devices or smartphones. The usual factors targeted through real-time interventions, included mental state of the driver (i.e. fatigue, drowsiness, distraction, stress and emotions) as well as driving performance (i.e. speed, harsh acceleration/braking, safety distance and lane-keeping). Technologies corresponding to four modes (car, truck, bus and rail) were examined, to identify systems that might perform better in a specific mode. Findings showed that there was a variety of technologies and applications for safety interventions associated with risk prevention and mitigation that could efficiently lead to improved driving performance.

Keywords: real-time interventions, driver monitoring, in-vehicle feedback, driving behaviour.

1. Background

The potential influencing factors that affect the likelihood of road crash occurrence and the ways to reduce them have been of major interest for researchers. To that end, the use of in-vehicle real-time intervention technologies prove to be an efficient solution. Providing drivers with relevant and concise, as well as comprehensive and timely information is of paramount importance, allowing them to understand and react to a risky situation in a sufficient time. Usual factors targeted through real-time interventions, include mental state such as fatigue, drowsiness, distraction, stress and emotions (Bergasa et al., 2006; Katsis et al., 2008; Kurian and Rishikesh, 2013). as well as driving behaviour in

[1] Further general project information can be found on the website: https://idreamsproject.eu

terms of speed, harsh events, safety distance and lane keeping (Adell et al., 2011; Butakov and Ioannou, 2014; Movig et al., 2004).

Taking into consideration the importance and the effectiveness of real-time interventions, the European Commission H2020 project i-DREAMS aims to develop and test an innovative context aware driver monitoring platform that provides interventions to drivers so as to maintain them within safe boundaries.

This paper is structured as follows: First, a general background of real-time interventions is provided. Subsequently, the objectives of the current research as well as the methodology with evaluation tools are presented. Furthermore, the results of a transportation mode-specific literature review aiming to identify the most effective real-time interventions are mentioned. Lastly, the expected impact of this study as well as considerations about technologies for real-time safety interventions with regards to the i-DREAMS project are highlighted.

2. Objectives

The objective of this research is to present a review and comparative assessment of a variety of real-time safety intervention strategies and technologies for each transport mode (car, truck, bus and rail), with the explicit purpose of ranking them based on how effective they are towards road safety outcomes. It is worth mentioning that tram and train consist a rail public transport system. Technologies are distinguished on their modality and are assessed based on their acceptance by the users.

3. Method

A standardised coding template was utilized to record key data from individual studies and concrete guidelines for summarising the findings per real-time safety intervention technology. Literature was searched within scientific databases such as Scopus, PubMed, ScienceDirect and Google Scholar. Table 1 describes the key words used per factor analysed as well as the number of screened and included papers.

Table 1: Key words, screened and included papers per factor analysed

Mode	Key words	Screened papers	Included papers
Car	"real-time interventions" OR "in-vehicle interventions" OR "real-time feedback" OR "real-time technology" OR "feedback" AND "car drivers" AND "cars"	71	6
Truck	"real-time interventions" OR "in-vehicle interventions" OR "in-vehicle feedback" OR "feedback technology" OR "feedback" AND "truck drivers" AND "trucks"	48	5
Bus	"real-time interventions" OR "in-vehicle interventions" OR "in-vehicle feedback" OR "feedback technology" OR "feedback" AND "bus drivers" AND "buses"	23	5

Rail	"real-time interventions" OR "in-vehicle interventions" OR "real-time feedback" OR "real-time technology" OR "feedback" AND "trains" AND "trams"	10	1

4. RESULTS

The results of the literature demonstrated that real-time feedback was usually delivered via embedded devices or smartphones. Visual, auditory and haptic warnings or combinations of both were found to enhance driving safety and were the most popular among the studies investigated. In addition, dashboard displays, head-up displays, steering wheels and seatbelts were versatile and effective solutions for providing real-time feedback to drivers. Table 2 depicts an overview of the available real-time intervention technologies with respectively assessment, in terms of their acceptance and effectiveness.

Table 2: Assessment of real-time intervention technologies

Modality	**Technology**	**Assessment**	**Assessment**
V	Dashboard Display	🟢	versatile, can display detailed information, available in all cars
V	Head-Up Display	🟢	versatile, within line of sight
V	Augmented Reality	🔴	risk of distraction, not commercially available
V	Centre Console Display	🔴	far from normal line of sight
A	In-Vehicle Auditory System	🟢	overrides music, provides navigation, can be positioned in multiple locations (left/right)
H	Steering Wheel	🟢	intuitive to steering actions (lane keeping)
H	Driver Seat	🔴	limited information, no available solutions
H	Pedals	🟡	intuitive with regards to feet actions, contact is required, limited information and applications
H	Seatbelt	🟢	maintains contact with driver
V & A & H	Nomadic Devices	🟢	many different devices are available, many options for interventions, commercially available in all vehicles

Modality: V: Visual, A: Auditory, H: Haptic

Assessment in terms of Acceptance/Effectiveness: 🟢: High, 🟡: Medium, 🔴: Low

4.1 Cars

In-vehicle signal systems with an on-board display such as the multi-modal detection system, SASPENCE (Adell et al., 2011), as well as in-vehicle auditory platforms such as CarChip Fleet Pro were the most efficient real-time driver distraction detectors. These widespread technologies were highly acceptable as they were easy to install. Furthermore, multisensory wearable modules and optalert glasses were found to have a robust effect on both drowsiness and driving performance. Safe and eco-driving applications were a cost-effective solution to modify drivers' behaviour. For instance, DriveGain and Drivewise were found to assess driving risk more accurately (Tulusan et al., 2012; Arumugam and Bhargavi, 2019). Dutch navigation system and Zephyr BioModule Device were less effective and acceptable by the drivers due to possible distractions from driving (Van der Heiden et al., 2019; Paredes et al., 2018).

4.2 Trucks

Technologies that were utilized to detect and monitor truck driving behaviour in real-time were non-intrusive, mainly through a web-based safety platform. Driver monitoring systems such as FleetCam, SmartDrive SR4 platform, Bendix Wingman Fusion system and Nauto Prevent were found to improve driver reliability and safety, providing satisfaction to the truck operators. These real-time intervention technologies were found to be an important proactive solution with fewer distractions and collisions for professional operators. In contrast, Driveri vision-based platform was not utilized by non-professional operators and personal car users, due to the device's expensive cost.

4.3 Buses

Most of the state-of-the-art technologies in real-time bus interventions provided visual and auditory alerts to drivers. New technologies utilizing only cameras have also emerged but depend heavily on hardware. ZF Openmatics, WebFleet, and MixFleet were indicated as the best options for ensuring safety, operational efficiency and compliance. Only a few applications took eco-driving into account (e.g. Green Road Bus Telematics and Trimble). Actually, Trimble was found to be the most comprehensive intervention approach as it combined real-time and historic information to inform and consult drivers. Applications developed by fleet manufacturers, such as Daimler, Volvo or MAN were less transferable to other fleets.

4.4 Rails

It was revealed that Automatic Warning System and Train Protection and Warning System were the two safety systems fitted in the majority of trains (Connor and Schmid, 2019). Similar warning systems such as Automatic Train Protection and Train Protection System were the best on-train monitoring recorders which were designed to alert drivers on excessive speeds, providing auditory and visual warnings or signals in order to apply emergency braking if needed (Connor and Schmid, 2019).

5. Impact

This overview of real-time intervention technologies could be used as a basis for selection of suitable interventions for the i-DREAMS project and can be used as a reference by researchers and practitioners. Visual and auditory sensors or eye-tracking might have lower initial hurdles regarding acceptance in cars and trucks, while visual information is essential in real-time for rails. With the exception of trains/trams, in-vehicle devices with small size, sound alerts and smartphones could be easily modified and transferred. Nevertheless, interventions targeting driver capacity aspects that combine driving behaviour and operator's mental state are currently not available.

Finally, it is worth mentioning that real-time interventions would be triggered based on specific indication of the safety level of the environment, and hence, the selected interventions should be versatile and quick in providing feedback, but simultaneously should aim at being as less obtrusive and distractive as possible. Attention should be given on the exploitation of the sensors inside each vehicle so as to capture all the necessary aspects required for operator state enhancement and coaching.

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