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Real-Time Monitoring of Driver Distraction: State-of-the-art and Future Insights

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The i-DREAMS project

- 13 Project partners:
  - National Technical University of Athens

    Universiteit Hasselt, Loughborough University, Technische Universität München, Kuratorium für Verkehrssicherheit, Delft University of Technology, University of Maribor, OSeven Telematics, DriveSimSolutions, CardioID Technologies, European Transport Safety Council, POLIS Network, Barraqueiro Transportes S.A.

- Duration of the project:
  - 48 months (May 2019 – April 2023)

- Framework Program:
  - Horizon 2020 - The EU Union Framework Programme for Research and Innovation - Mobility for Growth

Introduction

- The i-DREAMS project aims to define, develop, test and validate a context-aware safety envelope for driving in a 'Safety Tolerance Zone' (STZ), with a smart Driver, Vehicle & Environment Assessment and Monitoring System

- Taking into account, driver background factors and real-time risk indicators and driving task complexity indicators, a continuous real-time assessment will be created to monitor and determine if a driver is within acceptable boundaries of safe operation (i.e. STZ)

- Testing and validation will be applied to car, bus and truck drivers as well as to tram and train drivers

Background

- Driver distraction is a major cause of vehicle crashes worldwide with an increasing importance
- Technological developments make massive and detailed operator performance data easily available, via new in-vehicle sensors that capture detailed driving style
- This creates new opportunities for the detection and design of customized interventions to mitigate the risks, increase awareness and upgrade driver performance, constantly and dynamically

Driver Distraction Measures

- Driver distraction is a multidimensional phenomenon and there is not a unique driving performance measure which is able to capture all effects of distraction
- Visual distraction has a greater effect on lateral control measures, whereas cognitive distraction effects more visual scanning behaviour
- Among all trackable parameters, longitudinal and lateral control measurements, surrogate safety measures, such as reaction time or gap acceptance, and eye or head measures are deemed to be the most crucial to identify driver distraction

Driver distraction measures	Indicators
Longitudinal control	speed, headway
Lateral control	lateral position, steering wheel control, standard deviation of steering wheel angle
Reaction time	perception response time, brake response time, time-to-collision
Gap acceptance	number of collisions, gaps accepted
Eye movements	glances, saccades, fixations, blinks, gaze direction, eyes-off-road-time, electrooculography, percentage of eyelid closure time (PERCLOS), percentage of time spent not looking ahead (PERLOOK)
Head movements	rotation, orientation, pose

Methodology

- Review and assess state-of-the-art in-vehicle approaches and technologies as well as the various driver recording tools to monitor the driver's distraction and inattention
- A comprehensive literature search was conducted
- Identified measurement methods and associated technologies were assessed based on pre-defined criteria such as intrusiveness and effectiveness among others
- The transferability of the results to different transport modes (i.e. cars, buses, trucks and trains/trams) was assessed

Measurement/ indicators	Search terms
Performance	Driving ability/behaviour, lane crossings/maintenance/deviation/departure, steering movements, steering wheel variability, speed, decision-making ability, situational awareness, missed traffic signals, missed checks, longitudinal/lateral, event detection, SPAD's, subjective sleepiness, collision avoidance warning systems, pedal use, violation, secondary task engagement, eyes off road/target, braking, harsh braking, headway
Physiological	Blink rate, heart rate, EEG, eye/lid closure (PERCLOS), yawning, head nodding, eye movement, heart rate variability, ECG, eye tracking, pulse, galvanic skin response, blood pressure, skin conductance, cortical activity, biochemical markers, driver state monitoring, electrodermal activity
Mode	Car, bus, coach, truck, lorry, train, tram, rail, driver, professional driver, commercial driver, vehicle, automobile
Study	Simulator, real world driving, instrumented vehicle, natural driving study, filed operational test/trail

Results

- The results of the literature review revealed a variety of different sensors and systems that have been selected to detect driver distraction

- The research literature documents two types of measures associated with periods of distraction or inattention:
  - physiological indicators
  - behavioural indicators

Physiological Indicators

- Seeing Machines is an effective and non-intrusive face and eye-tracking system, monitoring the movements of a person's eyes, face, head, or facial expressions and distraction events in real-time through in-cab sensors and cameras

Source: Seeing Machines, 2020

- Empatica E4 Wristband is a wearable device, equipped with sensors that offers real-time high-quality physiological data (effective, easy to use and non-intrusive technology for the identification of driver distraction)

Source: Empatica E4 Wristband, 2020

- Tobi eye-tracking glasses are less effective for monitoring driver distraction as the calibration of eye tracker might be time-consuming (not suitable for on-road trials)

Source: Tobi eye-tracking glasses, 2019

Behavioural Indicators

- Mobileye is a forward facing camera, which alerts drivers when an imminent rear-end collision is looming, helps to keep a safe following distance, warns then about unintentional lane departures and provides indications about the detected speed limit signs

- CarSafe is a driver safety application, which detects dangerous driving conditions as well as inattentive driving and alters drivers, accordingly

Source: Mobileye, 2022

Discussion

- Non-intrusive technologies were strongly preferred for measuring inattention, and vision-based systems have appeared to be the most attractive for drivers

- Attention monitoring systems, including real-time head, gaze and eye tracking systems, sensors on steering wheels, wearables and dashboard cameras were found to be the most frequent devices to monitor and detect the driver's distraction, with head position, viewing and scanning patterns and PERCLOS being the most reliable indicators

- Smartphone applications which can provide measures such as lateral and longitudinal acceleration, can be utilized for surrogate safety measures capturing observed distraction and inattention

- On the other hand, less frequent approaches included hand magnetic rings and glasses

Future Insights

- Although automation affects significantly driving behaviour, distraction remains a key road safety issue with new aspects that arise
- Driver distraction and vehicle distraction will be for the next decades two major crash causes
- By the identification of risky distracted driving profiles, based on simulator and naturalistic driving behaviour data:
  - targeted enforcement strategies can be developed
  - targeted advanced assistance systems preventing driver distraction will be established by vehicle manufacturers

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