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ADVANCED SAFE TRUCK CONCEPT
FINAL REPORT

MONASH University | ACCIDENT RESEARCH CENTRE

Ron Finemore TRANSPORT

VOLVO

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Program

KEY MESSAGES

1. Current best practice in managing driver fatigue and distraction levels for commercial / professional drivers use shift characteristics such as shift timing which are used to determine a driver's level of fitness.

2. With the implementation of effective driver monitoring technology, this study demonstrates the opportunity for policymakers to apply a more personalised approach to managing the risks associated with driver fatigue and affords flexibility with how hours of service are implemented in practice.

3. Accurate measurement of driver workload allows for the potential implementation of additional technology, such as automated features, to improve efficiency and productivity, while maintaining safety standards for the driver.

PROGRAM SUMMARY

PROGRAM CONTEXT

Driver distraction and drowsiness are universally accepted as key contributors to road fatalities and injuries globally [1-2]. Governments, regulators and industry bodies are focused on reducing the risks of distraction and drowsiness by implementing regulatory and policy guidance and by embracing technology, now widely available, to help drivers, operators and owners improve safety around the world.

According to BITRE, 2462 Australians were killed as a result of involvement in heavy vehicle crashes between 2005-2014, representing 17.5% of deaths on Australian Roads [3]. Driver drowsiness remains a significant contributing factor to road crashes worldwide, with reports suggesting that fatigue is present in 15%-44% of crashes in Australia [4]. Distraction is a similarly pervasive public health problem, accounting for some 21% of all crashes in Australia [5].

Advances in technology now enable transport operators to strengthen their ability to measure and monitor in-cab driver performance in real-time as a way of complementing existing company safety policies and further ensuring they meet OHS requirements [6]. The Advanced Safe Truck Concept project (ASTC), led by Seeing Machines in collaboration with the Monash University Accident Research Centre (MUARC), Ron Finemore Transport (RFT) and Volvo Trucks Australia was a three-year program aimed to better understand the real-world risks faced by trucking operations and their drivers, and then through this high quality research to enhance existing technological solutions.

Real-time in-vehicle monitoring of driver state has been shown to be an important pillar within contemporary safety management systems in the workplace. There are numerous approaches to driver monitoring that can include monitoring critical safety events (e.g., a lane departure), monitoring vehicle control inputs (e.g., steering, pedal use) as in some telematics systems and, in particular, camera-based approaches that assess measures related to head pose, gaze and eyelid behaviour – typically referred to as driver monitoring systems (DMS). The latter approach has been recognised in the European National Crash Assessment Program as the best method to address these issues [7].

PROGRAM ELEMENTS

Capturing and harnessing the right data is of paramount importance for the development of technologies such as driver monitoring. Essentially this refers to the requirement to capture data from a diverse array of individuals, who experience mild to extreme impairment, and who can be observed in both simulated and real-world operational environments where both driver behaviour and environmental conditions are more naturalistic. Collecting the right data also refers to the requirement to have strong and robust objective measures of driver state that form the ground truth for algorithm development.

MUARC Advanced Driving Simulator (top) and integration with Seeing Machines' Driver Monitoring System (bottom)

The ASTC project used an array of advanced technologies to detect driver 'state', which reflected how well drivers were managing the demands of driving. Due to the unique technical requirements of the project, Seeing Machines DMS was integrated into MUARC's Advanced Driving Simulator technology. The end result of this integration was a world-first driver state sensing suite. This sensing suite was fully integrated first with MUARC's existing car-based driving simulator, and for the first time in Australia, a full truck cabin (Volvo Trucks) was used to create an Advanced Truck Driving Simulator as part of this project. This complemented the existing full passenger car model (full Holden Commodore) already at MUARC, but also was the test-bed for the assessment of new Driver Monitoring technology developed and assessed in this project. Over 100 drivers were recruited to drive for up to 4 hrs each under varying levels of drowsiness and distraction. The resulting dataset comprised over 1700 verified microsleeps.

Concurrently, a naturalistic driving study was conducted with a real-world operational fleet from RFT with the aim of validating the findings from the simulator studies. Ten RFT trucks part of a fleet nominated by RFT for participation in the study were instrumented with a subset of the sensors integrated with the MUARC Advanced Driving Simulator and were observed for up to 6 months. In addition to the existing Seeing Machines' Guardian system (which is fitted in all RFT trucks and, for duty of care, was to remain operational throughout the ASTC project), DMS, time-of-flight, cabin-view webcam, Mobileye, and a forward-facing camera were installed.

Darren Wood piloting the EEG headset with the help of Shafiul Azam

Instrumentation of RFT trucks at Wodonga

PROGRAM SUMMARY

Participants were instructed to drive as they normally would in the course of their employment, with the sensing suite designed to initiate recording with vehicle ignition. To collect truth data on levels of driver drowsiness (without the use of obtrusive systems such as EEG or actigraphy), drivers were additionally required to complete a brief paper-based alertness scale during the scheduled breaks on their shift.

Dr Jonny Kuo presenting initial project findings at Intelligent Transport Systems World Congress in Copenhagen, Sep 2018

SUMMARY OF ON-ROAD DATASET

Number of vehicles	10
Number of trips	22215
Number of shifts	2482
Total distance	1705093.78 km
Total time	31187:43:47 hrs
Number of driver IDs	120

In March 2018, the naturalistic study was officially launched at Old Parliament House with MP Paul Fletcher in attendance with key stakeholders from Seeing Machines, Ron Finemore Transport, MUARC, Volvo Trucks Australia, the CRC-P program and the NHVR. In total, over 100 drivers enrolled to participate in the study, collectively driving 22000 trips across over 1.5 million km, resulting in the largest and most comprehensive dataset of its kind in the world.

Ron Finemore and MP Paul Fletcher at the project launch at Old Parliament House

Prior to the naturalistic driving study, a fully functional truck was provided by Volvo Trucks Australia to Seeing Machines' Canberra headquarters to facilitate testing of the sensing platform and refinement of the instrumentation process to ensure minimal disruption to RFT's operational schedule during the study itself.

Building upon these datasets was the 4th phase of the project in which novel HMI concepts associated with the target driver states were developed and tested at MUARC's simulator facilities. This related to how warnings were delivered to drivers when they were detected as being distracted or fatigued, and involved the design and installation of a Head-Up Display (HUD). This required considerable development work to first build and integrate the new driver warning system into the Truck Simulator.

Kyle Blay (2nd from left) explaining the instrumentation process to project partners

TECHNOLOGY IMPLICATIONS

From the simulator studies, camera based technology was found to be most effective in determining the drowsiness level of a driver when compared to other methods used such as steering wheel sensors. Compared to commonly used eye closure metrics, a drowsiness level metric using Seeing Machines' production grade Driver Monitoring System (DMS) correctly classified a greater proportion of safety critical microsleep events. Similarly, for distraction, simple eyes-off-road detection did not provide adequate measurement of driver distraction levels. Detection of distraction, using the Seeing Machines' production grade DMS technology, was more effective (than eyes-off-road) in measurement of real-world driver distraction behaviours.

Dr Mike Lenné introducing the project at the Driver Distraction and Inattention conference in Gothenburg, Oct 2018

Algorithmic improvements in Seeing Machines Driver Monitoring underpins the product's ability to deliver a competitive service within the marketplace as well as working to foster driver acceptance of our service. Algorithmic improvements also reduce the total cost of delivering the service with the number of times the system intervenes in the cab being directly related to the cost of delivering the service as each time an intervention occurs data is sent to the cloud service. As Guardian's subscriber numbers grow it is expected that our algorithmic performance will increase so the service can continue to be delivered without a corresponding increase in required support within the existing teams. Future products will benefit from the improved driver state features that are being derived in part from the in-depth data captured during this program.

A key issue affecting the efficacy of any in-vehicle technology is the user interface, including how information is transmitted to operators, and its usability and acceptability among drivers. Within the context of driver monitoring technology, this includes defining the most effective warnings for heavy vehicle drivers and how they should be delivered given the driver's operational constraints, their driving task, and other technologies present in a truck's cabin.

A multi-stage human-centred design process (including driver interviews and design workshops) was used to develop core design specifications for driver fatigue and driver distraction systems which were then tested against an inspection-based evaluation and among a group of car and truck drivers (user-based evaluation). The developed HMI concept comprised a multi-modal warning system (visual, auditory and tactile) with two levels for driver fatigue and an escalating system for driver distraction. Subsequent testing showed that this concept was a) perceived by drivers to be efficacious, and b) had a high level of end-user acceptability and usability.

Truck simulator build in progress at MUARC using cab provided by RFT

POLICY IMPLICATIONS

Current best practice uses shift characteristics to determine a driver's fitness to drive - this was supported by our data, where drowsiness was linked with shifts commencing in the middle of the day and shifts of covering longer distances. In line with the recent research report from the National Heavy Vehicle Regulator [8] on fatigue detection technologies, project findings to date additionally support the efficacy of the real-time monitoring of driver drowsiness.

Not all drivers in the naturalistic study were equally affected by drowsiness, with the drivers most affected being over 3 times as likely to experience drowsiness than those in the lowest percentiles. In most shifts involving drowsy driving, drivers showed signs of drowsiness within 10 minutes of starting their shift. Conversely, some drivers approached maximum hours of service without showing signs of drowsiness.

Complementary to currently available aftermarket solutions for event detection, driver state monitoring in the context of heavy vehicles can empower drivers and fleet owners to make more informed decisions around shift scheduling and driver training. As a greater number of heavy vehicle fleets begin to adopt similar technology, it becomes increasingly pertinent to review the safety impact and ongoing relevance of prescriptive schedule-based approaches to fatigue management.

Ron Finemore at the launch of the Advanced Safe Truck Concept in Canberra

CONCLUSION

The three-year program utilised new data analysis methods to understand the behavioural risks in ways not previously possible. This was enabled by bringing together 'big data' analytics, simulation and computer vision expertise across Seeing Machines and Monash University and the operational and industry expertise of Ron Finemore Transport and Volvo Trucks Australia.

While the scientific findings provide significant new insights to characterise drowsiness and distraction and links to safety events, the real value from the program is in how this information is used to generate enhanced algorithms that measure driver drowsiness and distraction in real-time. The program produced algorithmic improvements that are now incorporated into Seeing Machines product development programs.

In addition to the technical achievements in this project, a key point of difference with ASTC was the level of collaboration that was achieved with the project partners. Prior to the naturalistic driving study, a fully functional truck was provided by Volvo Trucks Australia to Seeing Machines' Canberra headquarters to facilitate testing of the sensing platform and refinement of the instrumentation process to ensure minimal disruption to RFT's operational schedule during the study itself. The level of engagement from RFT management throughout the project was a strong driver in the project's success, realised through high participant retention during the naturalistic driving study.

As one of Seeing Machines' flagship research programs, ASTC is an example of a human factors-driven approach to product development in which research expertise is leveraged from leading university groups like MUARC, whilst directly engaging with customers like RFT.

This program not only established a number of world-first datasets showing the full range of target driver states, but accomplished this in a way that was scientifically defensible and validated extensively with real-world data from operational fleets. Supplementing data from existing, validated products, outputs from ASTC contribute to the next generation of driver monitoring technology with the ultimate aim being to prevent these crashes from occurring in the first place, and to protect the drivers who are on the road.

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