SEEING MACHINES LIMITED

NHTSA REQUEST FOR INFORMATION: IMPAIRED DRIVING TECHNOLOGIES

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For further information about this submission please contact:

Dr Mike Lenné

Chief of Human Factors & Safety

e: mike.lenne@seeingmachines.com

T +61 6103 4700

80 Mildura Street, Fyshwick ACT 2609, Australia

seeingmachines.com

seeingmachines

1. SUMMARY

- Seeing Machines believes that camera-based driver monitoring systems (DMS) will become the primary vehicle technology to detect driver intoxication.

- There is an increasing global mandate for DMS systems, led by the European Commission's statement that all new vehicles sold in Europe from 2022 must have new technologies including driver monitoring. This is supported by Euro NCAP programs that will award points for DMS systems starting 2023.

- Camera-based DMS systems are fully mature and currently deployed in light vehicles and trucks around the world as both aftermarket and OEM-installed products.

- The use of DMS for alcohol intoxication is a current area of research and development. The link between ocular metrics and intoxication is very robust.

2. INTRODUCTION

Seeing Machines is pleased to respond to the National Highway Traffic Safety Administration's (NHTSA) request for information on Impaired Driving Technologies (IDT). As a company that continuously advocates for road safety, we are very supportive of the NHTSAs plans to conduct research on IDT and appreciate the opportunity to provide information regarding our technology. Over the past two decades, Seeing Machines has established itself as an internationally recognized industry leader in camera-based Driver Monitoring Systems (DMS), providing a range of embedded DMS solutions for the OEM automotive industry and complete DMS products and services for fleets across the globe.

There is drive by governments, regulatory bodies, academia and the automotive industry to introduce new measures to improve vehicle and road user safety. The European Commission (EC), in particular, has been very active over the past five years in assessing a wide range of technologies that could be introduced to reduce injury, while also considering how they could be incorporated into crash assessment programs such as the Euro NCAP standard (The European New Car Assessment Program).

Driver monitoring, or occupant status monitoring, is one of the new safety measures that is currently being introduced into vehicles as a primary and active safety measure. It is a recommended approach to managing the risks associated with distracted and impaired driving in non-automated vehicles and is becoming a requirement for semi-automated vehicles [1]. There is ample crash data available from organizations in the EC and the United States (e.g., National Highway Traffic Safety Administration, Federal Highway Administration, National Transportation Safety Board), as well as other regions around the world, that highlights the role of distraction and impairment in road crashes.

Seeing Machines has a unique perspective to offer regarding the effective introduction of the DMS technology. We have been developing camera-based DMS technology for almost 20 years. Our technology was initially deployed in heavy mining trucks during the mining boom in 2014 to monitor fatigue of driver/operators working long shifts. Seeing Machines is also managing fatigue and distraction in heavy on-road truck fleets in more than 35 countries and over 26,000 commercial vehicles worldwide. Through its Guardian Fleet monitoring program, Seeing Machines receives in real-time video and alerts which are not only used to alert the fleet operator, but the video and data is also used to continuously improve our technology. Seeing Machines DMS technology is also available in OEM automaker production vehicles on the road today, including as a key component in the highly acclaimed General Motors Super Cruise™ system. Seeing Machines' expertise in the market is why six top global OEM automakers have chosen our DMS for production, including all three major U.S. automakers [2].

Seeing Machines is one of very few companies in the global automotive supplier base that heavily invests in Human Factors behavioral research, specifically regarding fatigue and distraction, using a multi-disciplinary approach to gathering data. This research and data underpins our development of detection and tracking algorithms, as well as allowing us to consult with both Tier One automotive electronics suppliers and OEM automakers on effective Human-Machine Interface (HMI) techniques to warn drivers in varying states. Because of this Human Factors-based research and data collection, Seeing Machines currently represents Tier Two DMS technology suppliers as an active participant in the Euro NCAP Occupant Status Monitoring Working Group (OSMWG), as well as consulting with the European Commission regarding the upcoming General Safety Regulation 2 (GSR2) standard for DMS in SAE Level 3 and 4 automated driving systems. We are also in regular discussions with the Australia NCAP team as well and continue to expand our direct relationships with government and safety regulatory and rating bodies worldwide.

Within the enclosed information, we demonstrate that our existing DMS products have validated capabilities to detect driver impairment arising from fatigue and distraction. The core technology behind these market-ready DMS products is fully equipped to capture the necessary signals for developing additional features to detect impairment caused by alcohol and other substances. We also highlight that our continued research towards developing such features is based on the understanding that camera-based DMS provide a unique opportunity to fill the gap between estimation of intoxication levels through measures such as blood alcohol concentration (BAC) and real-time detection of alcohol or drug-induced impairment. It is our opinion that such features will pave the way for future development of holistic DMS that can detect overall driver impairment irrespective of the cause and, as a result, improve traffic safety more broadly.

3. DRIVER MONITORING TECHNOLOGY

Our technology utilizes automotive-grade driver-facing infrared cameras, low-cost automotive qualified embedded processing silicon, advanced computer vision algorithms and software to determine driver state through assessment of subtle biobehavioral changes. Given that eye movements are both essential for driving and highly susceptible to states of fatigue, distraction and intoxication [3–5], various parameters of gaze and blink metrics are integral signals for the detection of driver impairment. Our core technology has been specifically developed to

accurately capture and process these subtle, but critical, biobehavioral changes that indicate a shift in cognitive performance and often precede detectable decline in vehicle control (i.e. indirect vehicle-based impairment methodologies and metrics).

DMS is being deployed at an increasing rate worldwide, with DMS installation rates projected to increase from 1% in 2019 to 71% by 2026 [6]. This rapid uptake of DMS is driven in part by recognition of the extensive safety benefits of DMS by regulatory bodies globally, with Euro NCAP set to mandate vision-based DMS in all new vehicles beginning in 2024.[4] The push for DMS uptake is further accelerated by the increasing automation of new vehicles and the need to ensure the safety of both driver and the public when testing automated vehicles. In September 2019 following a number of automated vehicle crashes the US National Transportation Safety Board (NTSB) recommended establishing *"safeguards for testing developmental automated vehicles on public roads, including adequate monitoring of vehicle operator engagement, if applicable"* [7]**.** With the automated vehicle market projected to grow to encompass ~85% of light vehicle production by 2026, DMS will be key for managing the human-machine interface and ensuring operator engagement and safety during driving [6].

Seeing Machines' DMS products have proven and validated capability to differentiate driver impairment associated with fatigue and distraction and reduce impaired driving rates through real-time alerting mechanisms [8,9]. Our mature fatigue detection algorithm has been repeatedly evaluated in operational settings through collaborative engagements involving external researchers and clients using the product, with resulting insights making significant contributions towards informing driver fatigue management policies in Australia [10,11]. Our algorithm to detect driver distraction is also backed by extensive research examining head position and gaze allocation across a range of distraction types (e.g, manual vs cognitive distraction) and in various driving situations including semi-autonomous vehicles [8,12]. In a recent evaluation of 17 ADAS by Consumer Reports (CR), engineers ranked Cadillac's Super Cruise, which features our FOVIO DMS algorithms, as the top performer noting its capacity to monitor driver attention [13.] The head of CR's connected and automated vehicle testing remarked *"even with new systems from many different automakers, Super Cruise still comes out on top due to the infrared camera ensuring the driver's eyes are looking towards the roadway"* [13].

The primary input utilized by our algorithms is real-time video from the driver-facing camera, with some vehicle metrics such as speed via the CAN bus serving as a secondary input to support classification of driver state. Our advanced computer vision algorithms meticulously map the driver's head and eye position and facial landmarks to accurately capture eye movements and blink activity. A variety of parameters of these movements (e.g. velocity and spatial location across multiple coordinate systems) are extracted as the primary signals to be used by our fatigue and distraction detection algorithms. Given that these primary signals are already available and have been validation tested for their accuracy, our existing DMS solution provides the necessary platform from which to develop additional features that can characterize how other forms of driver impairment, such as alcohol intoxication, alter attentional engagement and patterns of eye movement and, in the end, detect it.

4. SCIENTIFIC EVIDENCE TO SUPPORT INTOXICATION DETECTION

The role of eye movements for detecting internal cognitive state in applied settings is a rapidly expanding area of research. Extensive scientific evidence details how and why alcohol impairs visual attention and alters eye movement control which may result in detrimental effects for drivers. Alcohol impairment affects an individual's oculomotor control by decreasing the velocity and accuracy of glance behaviors and increasing the number and duration of fixations, impacting a range of cognitive processes relevant to driving ability [3,14]. It has recently been proposed that quantifying overall visual scanning efficiency can detect such changes [15], and preliminary findings suggest that not only can such metrics detect alcohol-induced impairment, but may differentiate levels of impairment across the BAC curve ranging from ascending to descending phases [16,17]. These alcohol-induced changes to driving behavior could be key targets for detecting drivers at risk of alcohol-related crashes, with alcohol-impaired drivers displaying significantly shorter anticipatory glances towards the turn before steering, which was associated with crash risk during simulated driving [18].

In addition to changes in visual scanning patterns, there are also changes to blinking behavior with alcohol intoxication, with the duration of eye closures and the percentage of time spent with eyes closed increasing with intoxication [19,20]. Seeing Machines technology already meets the specifications required to capture the necessary signals for generating these metrics. Seeing Machines has already developed a high-performance camera-based DMS capable of sophisticated eye and gaze direction tracking, as well as measuring eyelid aperture and blink velocity for monitoring driver drowsiness and distraction, and with the robustness of signal availability required when working in very difficult real-world automotive interior lighting conditions. There is significant overlap between certain elements of alcohol impairment and symptoms of distraction, such as changes to glance patterns, and drowsiness, such as changes to blink patterns, presenting a promising opportunity for detection of alcohol impairment using DMS. As such, we are currently engaged in both independent and collaborative research efforts to further explore and develop such metrics as means of detecting alcohol-induced driver impairment in the real world. Additionally, Seeing Machines is developing algorithms that make use of Wide Field of View (FoV) vehicle interior infrared cameras mounted centrally by the windscreen. While maintaining high performance head, eye gaze and eyelid tracking, the wide field of view of the camera will allow for development of algorithms that monitor the driver's torso to detect other potential mechanical abnormalities.

The challenge in assessing whether a driver's gaze patterns are efficient for the task at hand is that said efficiency can vary depending on the traffic environment. While existing methods suggest the possibility of utilizing gaze metrics to determine alcohol-induced decline in visual scanning efficiency, real-world application requires much more advanced implementation of such measures into adaptable algorithms that take into account the varying levels of visuo-spatial complexity in the traffic environment. This suggests that for DMS to be effective in detecting alcohol-induced impairment, they require input and processing from both driver-facing and forward-facing cameras, both of which are slowly becoming standard on light vehicles

Changes to driving performance also characterize acute alcohol intoxication, with drivers exhibiting an increase in drifting within lanes, speeding and steering wheel deviation [21]. Systems capable of monitoring these variables may offer some use for detecting alcohol impaired drivers, however, camera-based DMS combined with forward-facing cameras provide a number of advantages over the use of the of these indirect technologies alone. Firstly, distinguishing these behaviors from normal driving behavior often proves difficult without additional context, as outside of controlled simulated environments these variables are impacted by environmental factors such as traffic and road conditions. Furthermore, as driving becomes increasingly automated and ADAS features, such as cruise control and lane keep assist, become increasingly common, performance-based measures of driver impairment become redundant. Identifying alcohol impairment through camera-based DMS uses features of driver behavior that will remain robust in the face of increasing automation. Secondly, DMS has the advantage of the ability to monitor both distraction and drowsiness in real-time. Drowsiness, distraction and alcohol impairment can interact with one another in a way that increases driving impairment and magnifies the risk of a crash [22–24]. Utilizing camera-based DMS to directly monitor driver alcohol impairment in combination with drowsiness and distraction could allow for these interactions to be monitored and risk calibrated based on their combined effects.

With increasing availability of various levels of automation in new vehicles, inclusion of external (outward facing) cameras and sensors that monitor the traffic environment is becoming more commonplace in automotive production. This creates opportunities for integration-ready DMS like Seeing Machines FOVIO DMS, to incorporate assessment of driver and traffic state in order to effectively detect when a driver's attentional engagement and visual scanning behavior does not meet the demands of the traffic environment. We believe that such an approach to developing DMS will not only enable us to detect alcohol-induced impairment, but also impairment arising from other drugs, medications and illness that may affect attentional engagement and visual scanning behavior while driving.

5. FINAL REMARKS

The global drivers for DMS are in place. Camera-based driver monitoring has become center stage as regulators and policy-makers globally recognize it to be the critical ADAS technology of the decade. Led by the European Commission, which requires all new cars, vans, trucks and buses to be fitted with DMS from 2024, and Euro NCAP, where all new vehicles produced in Europe from 2023 will be awarded safety points toward their star ratings for including driver monitoring systems to protect against distraction and impairment, DMS is becoming a requirement. From 2025, these driver monitoring systems must be camera-based to attract any points.

DMS technology is mature and already in vehicles around the world. Camera-based DMS is used by trucking fleets around the globe to protect drivers, in real-time, primarily from distraction and drowsiness. The automotive industry is committed to using DMS as an enabler for assisted driving (L2 and above) to achieve enhanced safety and to power an expanding range of convenience features. Seeing Machines alone is deploying its DMS across production programs with six major automotive OEMs, in Europe, North America and China.

The science is in – ocular metrics hold the key to determining intoxication. There is ample evidence from research laboratories around the world that confirms that changes in ocular behavior, as captured through our DMS, can be used to reliably detect whether or not a person is intoxicated.

The industry is increasingly pursuing DMS applications for intoxication. Automotive and trucking OEMs and operators are already investing significantly in camera-based driver monitoring. The industry will be determined to derive additional value from the existing investments in this technology for addressing distraction and drowsiness, already demonstrated through enhancements of convenience features, such as with eye-tracking controlled infotainment. We can be certain, therefore, that using camera-based DMS to detect alcohol intoxication is becoming a more prominent focus for the industry as OEM automakers will want to optimize the use of the driver-facing cameras already being installed in their vehicles for other safety requirements.

Seeing Machines is leading this space both in safety research and development and business. At Seeing Machines, we exist to get people home safely. Our primary objective is to improve traffic safety. We have thus far successfully tackled the risk associated with fatigue and distraction by developing DMS that detect such impairments in real-time. Our continued focus on Human Factors research and collaborations with the scientific community, regulatory bodies and other stakeholders, has ensured that our products are developed with expert knowledge and strive to meet the key objective of improving traffic safety. Not surprisingly, developing features that target driver impairment associated with drug and alcohol intoxication is a current development focus. Seeing Machines welcomes on-going dialogue with NHTSA on the application of DMS technology to address DUI.

6. REFERENCES

1. Barnden, C. It's Time for Automakers to Get Serious About Safety. *EE Times* https://www.eetimes.com/its-time-for-automakers-to-get-serious-about-safety/ (2020).

2. Yoshida, J. Name the 'Mobileye' of Driver Monitoring Systems. *EE Times* https://www.eetimes.com/name-the-mobileye-of-driver-monitoring-systems/ (2020).

3. Silva, J. B. S., Cristino, E. D., Almeida, N. L. de, Medeiros, P. C. B. de & Santos, N. A. dos. Effects of acute alcohol ingestion on eye movements and cognition: A double-blind, placebo-controlled study. *PLOS ONE* **12**, e0186061 (2017).

4. Hayley, A. C., Shiferaw, B. & Downey, L. A. Amphetamine-induced alteration to gaze parameters: A novel conceptual pathway and implications for naturalistic behavior. *Prog. Neurobiol.* 101929 (2020) doi:10.1016/j.pneurobio.2020.101929.

5. Ftouni, S. *et al.* Temporal dynamics of ocular indicators of sleepiness across sleep restriction. *J. Biol. Rhythms* **28**, 412–424 (2013).

6. Barnden, C. ADAS & Automotive IR Vision Driver Monitoring Systems (2020 Edition) Market Analysis and Forecasts to 2026. 74 (2019).

7. NTSB. *Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona, March 18, 2018*. 78 (2019).

8. Yang, S., Kuo, J. & Lenné, M. G. Effects of Distraction in On-Road Level 2 Automated Driving: Impacts on Glance Behavior and Takeover Performance. *Hum. Factors J. Hum. Factors Ergon. Soc.* 001872082093679 (2020) doi:10.1177/0018720820936793.

9. Fitzharris, M., Liu, S., Stephens, A. N. & Lenné, M. G. The relative importance of real-time in-cab and external feedback in managing fatigue in real-world commercial transport operations. *Traffic Inj. Prev.* **18**, S71–S78 (2017).

10. National Transport Commission. *Heavy Vehicle Driver Fatigue Project*. https://www.ntc.gov.au/sites/default/files/assets/files/Heavy-Vehicle-Driver-Fatigue-Summary-Report.pdf (2019).

11. Shiferaw, B. A. *et al.* Fatigue among heavy vehicle drivers: the impact of shift-start times and time of day. 4 (2019).

12. Yang, S., Kuo, J. & Lenné, M. G. Analysis of Gaze Behavior to Measure Cognitive Distraction in Real-World Driving. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* **62**, 1944–1948 (2018).

13. Monticello, M. Cadillac's Super Cruise Outperforms Other Driving Assistance Systems. *Consumer Report* https://www.consumerreports.org/car-safety/cadillac-super-cruise-outperforms-other-active-driving-assistance-systems/ (2020).

14. Maurage, P., Masson, N., Bollen, Z. & D'Hondt, F. Eye tracking correlates of acute alcohol consumption: A systematic and critical review. *Neurosci. Biobehav. Rev.* **108**, 400–422 (2020).

15. Shiferaw, B., Downey, L. & Crewther, D. A review of gaze entropy as a measure of visual scanning efficiency. *Neurosci. Biobehav. Rev.* **96**, 353–366 (2019).

16. Shiferaw, B. A., Crewther, D. P. & Downey, L. A. Gaze entropy measures detect alcohol-induced driver impairment. *Drug Alcohol Depend.* **204**, 107519 (2019).

17. Shiferaw, B., Crewther, D. & Downey, L. A. Gaze Entropy Measures Reveal Alcohol-Induced Visual Scanning Impairment During Ascending and Descending Phases of Intoxication. *J. Stud. Alcohol Drugs* **80**, 236–244 (2019).

18. Marple-Horvat, D. E. *et al.* Alcohol Badly Affects Eye Movements Linked to Steering, Providing for Automatic in-Car Detection of Drink Driving. *Neuropsychopharmacology* **33**, 849–858 (2008).

19. Beideman, L. R. & Stern, J. A. Aspects of the Eyeblink during Simulated Driving as a Function of Alcohol. *Hum. Factors* **19**, 73–77 (1977).

20. De Blasiis, M. R., Ferrante, C. & Veraldi, V. Driving Risk Assessment Under the Effect of Alcohol Through an Eye Tracking System in Virtual Reality. in *Advances in Safety Management and Human Factors* (ed. Arezes, P. M.) 329–341 (Springer International Publishing, 2020). doi:10.1007/978-3-030-20497-6_31.

21. Weafer, J. & Fillmore, M. T. Acute tolerance to alcohol impairment of behavioral and cognitive mechanisms related to driving: drinking and driving on the descending limb. *Psychopharmacology (Berl.)* **220**, 697–706 (2012).

22. Anderson, C. & Horne, J. A. Driving drowsy also worsens driver distraction. *Sleep Med.* **14**, 466–468 (2013).

23. Banks, S., Catcheside, P., Lack, L., Grunstein, R. R. & McEvoy, R. D. Low Levels of Alcohol Impair Driving Simulator Performance and Reduce Perception of Crash Risk in Partially Sleep Deprived Subjects. **27**, 5 (2004).

24. Harrison, E. L. R. & Fillmore, M. T. Alcohol and distraction interact to impair driving performance. *Drug Alcohol Depend.* **117**, 31–37 (2011).