Edge Intelligence 2022, Emerging Tech Conference

Real Time Drowsiness Detection, Alerting and Reporting

Athanasios D. Balomenos[a], Dimitrios Xynogalas[a], Vasileios-Marios Panagakis[a], Andreas Georgis[a], Georgios Siokas[a], Yannis Kopsinis[a,*]

[a]*LIBRA AI Technologies IKE, Evristheos 2, Athens, 11854, Greece*

* Corresponding author. Tel.: +30-210-444-1973 . *E-mail address:* yannis.kopsinis@libramli.ai

Abstract

Driver drowsiness is one of the leading causes of motor vehicle crashes, an issue which the industry and academia wants to tackle. Currently, different methodologies focus on combining drowsiness detection technologies and machine learning. The proposed solution is a computer vision-based solution for detecting drowsiness based on a video feed of the driver's face. This helps monitor a driver's fatigue condition in real-time. The system is based on a hybrid approach, combining the decision of far-edge and near-edge submodules to detect drowsiness signs of the truck driver. According to the drowsiness level, the system will trigger an alert, e.g., by sounding an alarm that will be installed in the truck's cabin. The proposed solution will be implemented in the Piraeus Container Terminal (PCT).

Keywords: Machine Learning; Artificial Intelligence; 5G Technologies; Drowsiness Detection Technologies;

1. Introduction

In the United States, shift workers, comprising 15% of the workforce, are at particular risk of drowsy during vehicle operations [1]. According to [2], around 60.5% of crane operators continue to work even while having signs of drowsiness or fatigue. Employees with drowsiness are 70% more likely to be involved in work-related accidents [3]. Most safety systems developed for detecting drowsiness are not widespread as it is an additional module to a heavy machinery vehicle and not included by the manufacturers.

DD technologies can be classified into three main categories. The first category involves measuring cerebral and muscular signals and cardiovascular activity, which is invasive and not commercially viable. The second category includes techniques of measuring overall driver behaviour from the driving patterns, which cannot detect the driver's micro-sleeps (sleeping for a few seconds). The third category consists of ways to monitor the driver's sleepiness, using Computer Vision techniques [3], [4], and its purpose is to detect the state of specific signs and indications, e.g., facial features such as the eyes giving cues of an increased or prolonged blinking, that humans perceive as drowsiness.

Far edge devices along with emerging deep neural network architectures, led to ground-breaking advances in real-time drowsiness detection systems [4]. However, such solutions are exceedingly difficult to be applied in fleets of many vehicles due to the prohibitive cost of powerful edge devices and the high computational need of deep learning architectures. Furthermore, DD in heavy machinery is far more challenging compared to automobiles. The size of cabin and the type of working site may lead to variant lighting conditions (e.g., day/night shifts, tunnels, headlights, and weather). Heavy machinery vehicles are highly vibrating also leading to erratic movements the video camera. Also, the machine operator position changes considerably due to soft seat suspension. Another remarkable issue is that false alerts may distract the drivers leading to more accidents.

We propose herein a relatively low-cost solution which will provide, reliable real-time drowsiness detection by distributing computational power needs between far and near edge over 5G. This hybrid solution will detect drowsiness based on classical approaches in the far edge, if connectivity issues or emergency case occur, otherwise it will communicate with the near edge in order to make a more accurate prediction exploiting deep neural network architectures. A major goal in our approach is to achieve a low rate of false positives since they are highly distractive for the operators, and they compromise trust in the DD system. It considers operators privacy (GDPR compliant approach) because it will not stream the video segments directly to the far-edge device, but it will send video embeddings which are non-reversible, coded versions of the video frames. Overall, it will increase operators' safety and reduce considerably the costs related to accidents.

The proposed solution will be demonstrated in one of the busiest container terminals in Europe, the Piraeus Container Terminal (PCT) port in Greece. The Piraeus port is currently ranked 4th among the busiest European Ports of 2020 in terms

DRAFT

of container throughput and is presently moving about 5.5 million TEUs on an annual basis. In PCT, a mother vessel requires an average of 3000 stevedore moves for operation completion, e.g., for loading/unloading all containers that have either as final or intermediate destination the Port of Piraeus. DD in heavy machinery operators, e.g., truck drivers or crane operators, is of paramount importance for their safety and the seamless terminal functionality.

2. Proposed DD System

2.1. The architecture of the proposed solution

Figure 1 provides a high-level description of our computer vision-based solution. The far edge submodule captures a video HD feed from the machine operator. Then, it applies advanced face detection to extract and track along time the region containing their face and proceeds with drowsiness detection based on lightweight baseline approaches exploiting the position and shape of key facial features, including the eyes, nose, mouth, chin, eye-aspect ratio (EAR) [5], and mouth-aspect ratio (MAR)) in a PERCLOS [6], alike approach, to perform a baseline drowsiness assessment. Simultaneously, it extracts the face embeddings from the videos, using the first layers of 3D CNN architecture [7]. Finally, it sends the embeddings to the near-edge module via the 5G network. The low latency of 5G enables the two modules interconnection and cooperation.

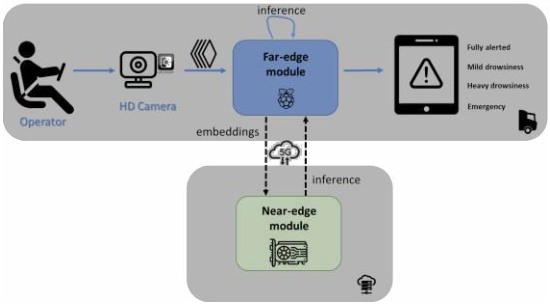

Fig. 1. A hybrid approach providing real time drowsiness detection by combing far-edge (in the truck) and near-edge (server) resources over 5G technology. The far-edge module may operate as a stand-alone application whenever there are connectivity issues with the near-edge or when emergency situations occur.

The near-edge module receives the operator's embeddings. By using a complex architecture comprising of a 3D CNN along with LSTMs [7], the module will have to assess the drowsiness levels of the operator. This type of architecture allows the module not only to learn image related features but also time dependencies of such features. Then, it returns the assessment back to the far-edge module. Furthermore, it will use its predictions to compute drowsiness profiles and define the emergency threshold to be set in far-edge module. Finally, the module will store its predictions in analytics ready form for further analysis by human experts.

Based on the output of both modules the proposed system will alert the operator in real-time when it detects the drowsiness symptoms. Specifically, according to the drowsiness level, it will trigger an alert, e.g., by sounding an alarm, installed in the vehicle's cabin or by triggering another similar alerting functionality.

2.2. System evaluation

The system will be assessed based on three major KPIs: (1) the event to alert time (EAT), which indicates the time lag between an emergency drowsiness event (such as nodding off) and the delivery of the alarm, (2) the false positive rate (FPR), which is the rate of video segments that were normal yet estimated by the system as positive (i.e., indicating a drowsiness sign), and (3) the false-negative rate (FNR), which is the rate of video segments that were falsely characterized as normal, however, they were exhibiting drowsiness signs.

3. Conclusion

The proposed solution highlights:

- It will provide a low-cost solution for drowsiness detection that can be applied in heavy machinery fleets
- It will alert the operator in less than 2 seconds from the drowsiness incident
- It respects the privacy – no video stream is recorded or transmitted outside the vehicle
- The solution provides a central data repository that enables an advanced reporting system (certain distraction and drowsiness KPIs) that will offer a 360º view of the alertness of the fleet playing a critical role in decision making to further reduce the possibility of drowsiness-induced accidents

Acknowledgements

This paper is part of the 5G-LOGINNOV project, co-funded by the European Commission under the H2020 Research and Innovation Program (grant agreement No 957400).

We thank PCT (info@pct.com.gr) for their support and help in the functional specifications of the project.

References

[1] M. L. Lee *et al.*, "High risk of near-crash driving events following night-shift work," *Proc Natl Acad Sci U S A*, vol. 113, no. 1, pp. 176–181, Jan. 2016, doi: 10.1073/PNAS.1510383112/SUPPL_FILE/PNAS.1510383112.ST02.XLSX.

[2] V. W. Y. Tam and I. W. H. Fung, "Tower crane safety in the construction industry: A Hong Kong study," *Saf Sci*, vol. 49, no. 2, pp. 208–215, Feb. 2011, doi: 10.1016/J.SSCI.2010.08.001.

[3] V. Saini and R. Saini, "Driver Drowsiness Detection System and Techniques: A Review," 2014, Accessed: Sep. 12, 2022. [Online]. Available: www.ijcsit.com

[4] L. Oliveira, J. S. Cardoso, A. Lourenço, and C. Ahlström, "Driver drowsiness detection: a comparison between intrusive and non-intrusive signal acquisition methods," *7th European Workshop on Visual Information Processing (EUVIP)*, pp. 1–6, 2018, Accessed: Sep. 12, 2022. [Online]. Available: https://repositorio.ipl.pt/handle/10400.21/9870

[5] T. Soukupová, "Real-Time Eye Blink Detection using Facial Landmarks".

[6] S. Junaedi and H. Akbar, "Driver Drowsiness Detection Based on Face Feature and PERCLOS," *J Phys Conf Ser*, vol. 1090, no. 012037, pp. 1–7, 2018, doi: 10.1088/1742-6596/1090/1/012037.

[7] S. A. Alameen and A. M. Alhothali, "A Lightweight Driver Drowsiness Detection System Using 3DCNN With LSTM," *Computer Systems Science and Engineering*, vol. 44, no. 1, pp. 895–912, 2023, doi: 10.32604/CSSE.2023.024643.

Edge Intelligence 2022
EMERGING TECH CONFERENCE



DRAFT

ETiA
EXPANDING THE DIGITAL FRONTIERS

ΠΑΝΕΠΙΣΤΗΜΙΟ ΠΑΤΡΩΝ
UNIVERSITY OF PATRAS

Patras IQ
Patras Innovation Quest