Sleepiness Detection and Alert System for Automobile Drivers

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Abstract - *Dozy Driving contributes to a large number of accidents every year across the world, so much so that worldwide of all the traffic accidents approximately 20% are related to fatigue driving [1]. Furthermore, it is estimated by the Transport Research Wing, MoRTH that drowsy driving causes around 1,796 deaths, 4,685 injuries, and more than around 4,500 accidents in the year 2016 alone in India [2]. To reduce such incidents, automobile manufacturers explore the idea of a sleepiness monitoring system in the vehicles, which would function to alert the driver and prevent them from falling asleep during driving. There are multiple ways to monitor driver sleepiness, such as using steering pattern, vehicle position in the lane, eye monitoring, physiological measurement etc [3]. The sleepiness monitoring system that we developed uses face detection, which is equipped with an infrared camera that monitors eye blinking even under low light conditions without obstructing the driver. In case a microsleep is detected, the system alerts the driver and records the current time simultaneously. If the system detects redundant behaviour, it sends a text alert to concerned authorities. Additionally, the system maintains a log that records the sleepy behaviour of the automobile driver that can be referred to in case of a mishap or an accident.*

***Key Words*: Dozy Driving, Sleepiness Monitoring, Face Detection, Eye Blinking, Microsleep, Sleepy behaviour.**

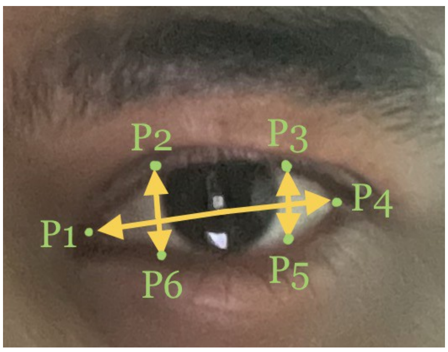
1. INTRODUCTION

Dozy driving is a major concern to automobile drivers, especially goods carriers and transports that majorly operate during nighttime because it's one of the most common causes of road accidents. Cruise control being a common feature in modern automobiles, the risk is only elevated as the chances of experiencing sleepiness is increased and post-accident damage is magnified. A sleepiness detection system functions by identifying sleepiness and alerting the driver to prevent any mishaps and hence improve road safety. This can be achieved by various methods that either focus upon drivers' physiological conditions, such as pulse measurement, eye blink rate detection, etc or vehicle's parameters such as lane position or steering pattern and input, each with varying degrees of success and depending on the method of measurement and detection used the cost and complexity of such systems vary widely [3].

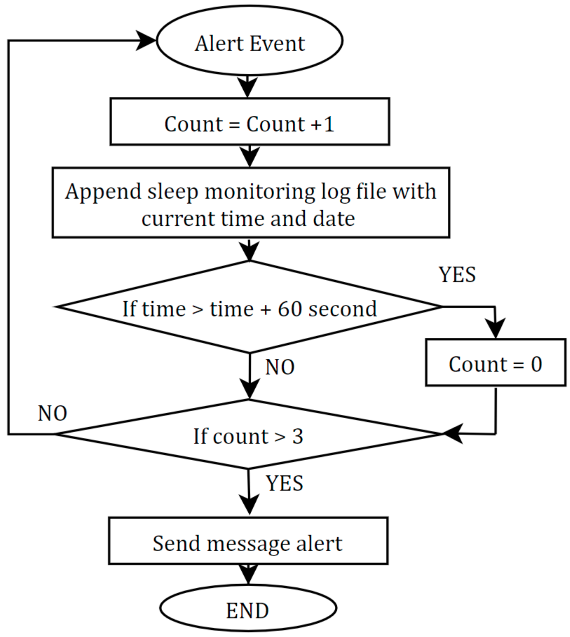
The sleepiness detection system developed by us employs an infrared camera that monitors the eye blinking rate of a human driver using face detection in real-time. The system detects microsleep and sleepy behaviour showcased by the driver and alerts them accordingly to take appropriate rest and discontinue driving in the current state. Despite the alerts, if one resists sleep, it becomes increasingly more difficult to do so the next time. Hence, if the driver showcases repeated behaviour despite the warnings within a short duration of time, it sends an SMS alert to the concerned authority of the vehicle or the driver of his repeated offence in the hopes of deterring his actions. In addition, the system also keeps a register that records every time a driver displays a sleepy behaviour which could be useful in case of mishaps or accident to determine the driver's condition at the moment.

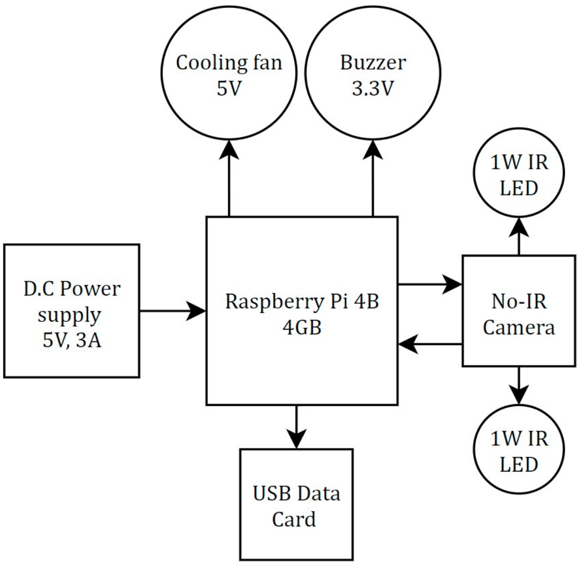
2. METHODOLOGY

The Sleepiness detection system has two major aspects in terms of development, software development and prototype development. We have used python programming language to write a code that utilizes OpenCV (Open-Source Computer Vision Library) and Dlib library for real-time face recognition. Using which we identify coordinates for left and right eyes as shown in Figure-1 using facial landmark localization [4]. After which we use the coordinates to calculate Eye Aspect Ratio (EAR) using the following formula:



EAR value serves as an index that describes the state of eyelids, which coupled with time measurements provides eye blink duration, which is then used to determine the driver's drowsiness and microsleep event. In case such an event occurs, the program rings an alarm and triggers an alert protocol as shown in Figure-2, to determine the necessary actions required.





A standalone prototype device is built for independent operation of the program, whose configuration is shown in Figure-3, that can be operated in the automobile with relative ease and minimal modification.

The system consists of a single-board computer, Raspberry Pi 4B, that initializes the sleepiness detection program at the startup when power is provided from the power supply. The power supply is made up of a buck converter that converts the car battery voltage (12V DC) to the required system voltage (5V) and a maximum current of three amperes. The computer is connected to a No-IR (No Infrared filter) camera, coupled with IR (Infrared) LEDs (Light Emitting Diode) that provide low light illumination without obstructing the driver's vision. A buzzer is used to alert the driver in case of a microsleep or sleepy behaviour. USB (Universal Serial Bus) Data Card is used to provide onboard connectivity for SMS (Short Message Service) alerts.

3. SYSTEM PERFORMANCE

The developed system operated as intended with full functionality without any setbacks. An experiment was designed to evaluate performance that simulated various life-like conditions. The system was altered to record the EAR value with the time of recording to better illustrate the results and performance

3.1 Setup of experiment

The system is tested in an actual stationary vehicle, placed in the front of the driver in a way that his complete face is visible in the camera feed. The relative distance between the driver and the tilt of the device is kept constant throughout the testing. The system is powered by the car battery itself through the 12 V DC (Direct Current) outlet present inside the vehicle. As our camera is capable of IR Vision in the daytime as well, we have considered the following conditions to evaluate the system performance.

1. Naked Eye under daylight (With IR)
2. Naked Eye under daylight (Without IR)
3. Naked Eye under dark/No-light Environment
4. With clear spectacles / prescribed glasses

3.2 Results

3.2.1 Naked Eye under daylight (With IR)

Chart-1 shows the plot of EAR values recorded with their respective time, where the driver performs normal blinks without any facial accessories, under daylight, and Infrared/Night vision turned on forcefully.

Chart-2 shows a similar plot but with the driver showcasing sleepy behaviour and microsleep patterns deliberately.

3.2.2 Naked Eye Under Daylight (Without IR)

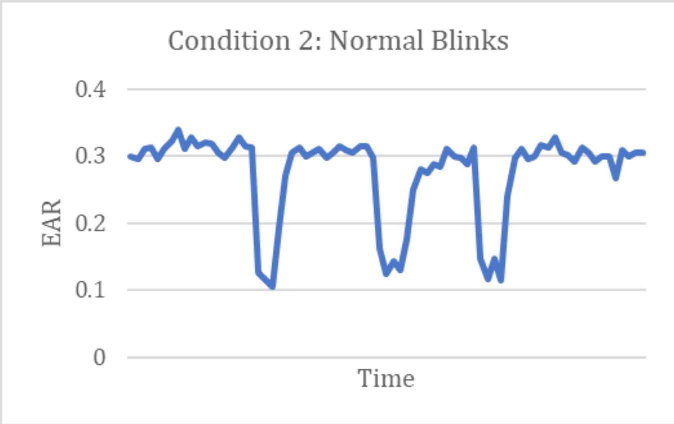


Chart-3 illustrates the EAR vs Time plot of the system which is tested under the daylight conditions as well, but where Infrared/Night vision is naturally off due to the abundance of light for the camera. The driver emulates normal blinks and has no facial accessories.

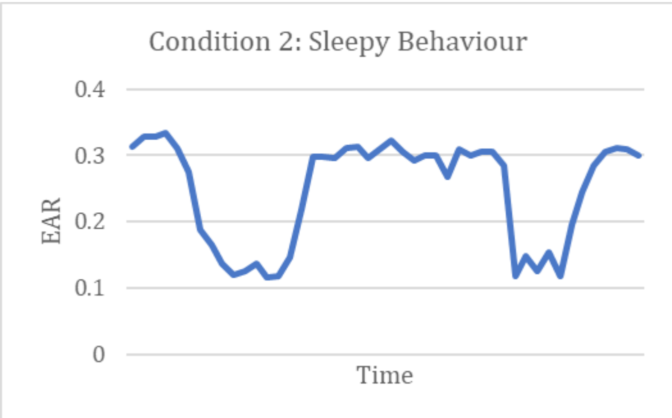
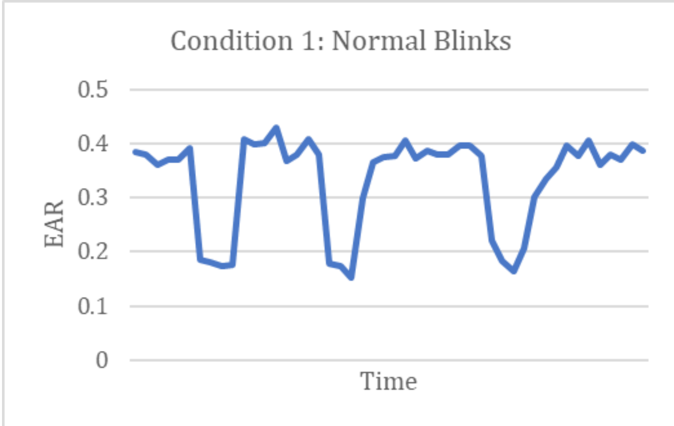


Chart-4 shows a similar plot but with the driver showcasing sleepy behaviour and microsleep patterns deliberately.

3.2.3 Naked Eye Under Dark/No-Light Environment

Chart-5 shows the plot of EAR values to time, where the driver performs normal blinks without any facial accessories, under dark and no light environment, and Infrared/Night vision turned on



naturally

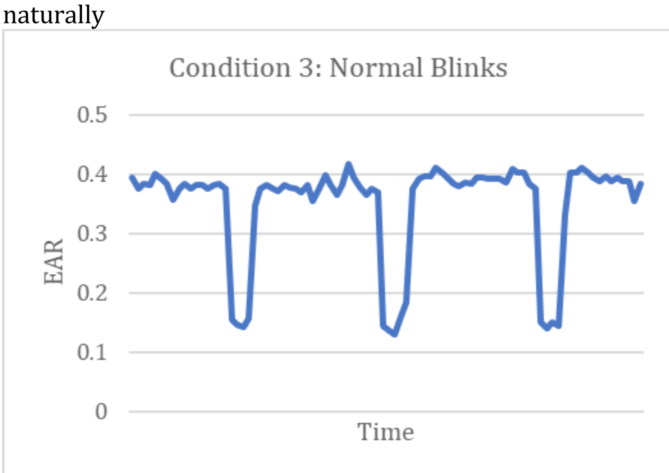
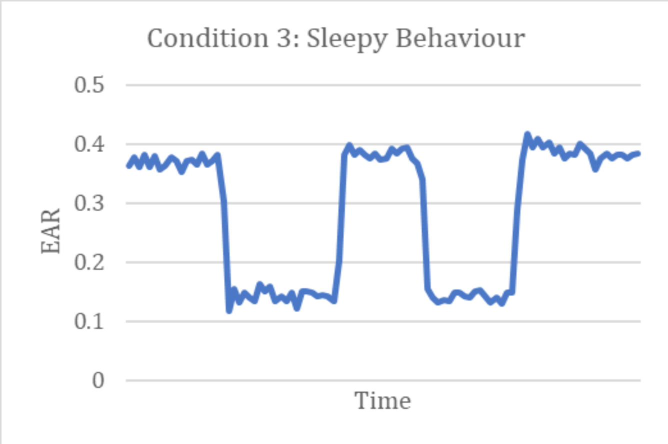


Chart-6 shows a similar plot but with the driver showcasing sleepy behaviour and microsleep patterns deliberately.



3.2.4 With Clear Spectacles or Prescribed Glasses

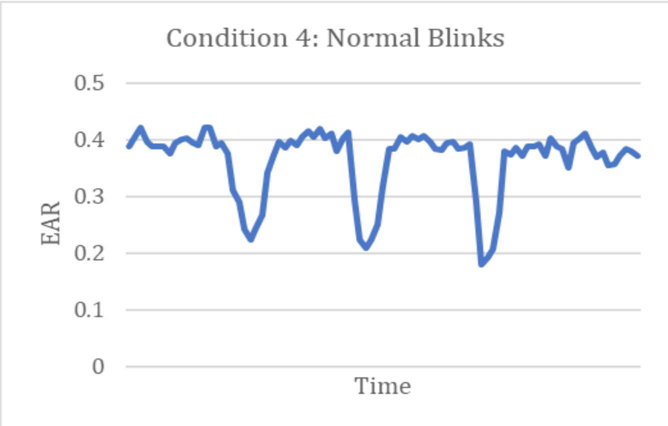
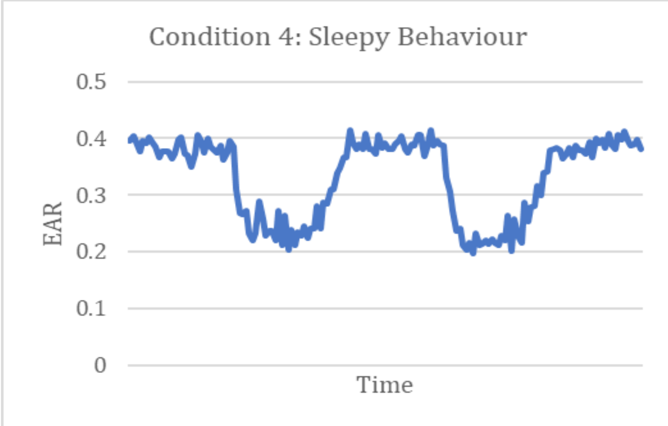


Chart-7 illustrates the EAR vs Time plot of the system which is tested with the driver using a clear spectacle (no tint or shade) or medically prescribed glasses that is a more common occurrence due to people with vision problems. The driver emulates normal blinks. As the previous tests have established that infrared vision in daylight produces similar results, and the system performs just as good under no light condition, hence the same test is not repeated for different combinations of light and infrared vision conditions.

Chart-8 shows a similar plot but with the driver showcasing sleepy behaviour and microsleep patterns deliberately.



4. CONCLUSIONS

The developed system functions as intended, with all additional features intact. It operates with no setback in vehicles, just as the same in laboratory conditions. Though the test results were not performed in an operating vehicle, but rather in a stationary vehicle, the outcome isn't believed to be much different, the accuracy will take a slight dip as operating conditions mean dynamic lighting condition, vehicle vibrations and movement of the driver.

The performed tests display reliable results under different conditions. The system can successfully differentiate between normal blinking and sleepy behaviour or microsleep events. The infrared vision does not affect the daylight conditions but vastly improves the no-light condition as all the results are similar within acceptable limits. However, when tested with prescribed glasses, the lower limit, i.e., eye closed readings are shifted up drastically, reducing variation between open and close eye, yet the system can differentiate between normal and abnormal blinking. It is subject to change with different aspects of glasses such as thickness, film coating, etc.

The system is also able to record and store the sleepiness behaviour data on the onboard memory card, which will remain intact and readable even without the host system. It is also able to successfully send text alerts when a repeated offence is detected, the text can be customized to include vehicle number and driver's contact information, and even without one, it could be identified easily with the SIM (subscriber identity module) information in the data card. The system shows promising performance and reliability, and could be used with modern vehicles relatively easily as a standalone attachment. It is also entirely possible to be included within the vehicles infotainment system for seamless integration with relatively lower investments and reliable performance. With the device employment, it can be a boon to road safety, for both passengers and pedestrians alike.

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