Original Article

Intelligent Driver Sleep Detection and Alerting System

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ABSTRACT

Transportation has already become a vital part of the daily routine of people all around the world. With the increasing demand for transportation, road traffic accidents have also been increasing exponentially. Further, road traffic accidents are found to be one of the critical causes of annual deaths, injuries, and damages worldwide. Among the minor and fatal crashes, distracted driving has been identified as one of the leading causes. Sleepiness/drowsiness or fatigue in drivers can be stated as the most common reasons, and as an unavoidable and unintentional cause for distraction, because most of the time the driver would not be aware of the condition until facing a critical incident. Therefore, identifying sleepiness/drowsiness at the initial stages, and alerting the driver, would contribute to minimizing the risk of such road traffic accidents. The paper presents an automated system that is capable of identifying sleepiness/drowsiness in drivers in the initial stages and immediately alerting the driver. Furthermore, given the criticality of the situation, the system also operates a new feature of simultaneously sharing the current location of the vehicle to a pre-defined close contact of the driver to further minimize the risks and as a prevention mechanism.

Index Terms: Eye aspect ratio, Location sharing, Open-source computer vision, Percentage eye closure, Raspberry Pi, Road traffic accidents, SIM808, Sleep detection.

INTRODUCTION

Transportation plays a vital role in society, therefore the usage of vehicles has rapidly Increased over time, and so have road traffic accidents. According to the statistics on 'The Global status report on road safety 2018', launched by the WHO (World Health Organization) in December 2018, the number of annual road traffic deaths has reached 1.35 million. Also, road traffic injuries have been identified as the leading cause of death for children and young adults aged 5-29 years. These road accidents have also caused 20-50 million more people to suffer non-fatal injuries, with some causing a disability as a result of their injury [11]

Sri Lankan statistics on the Global status report on road safety 2018 published by the WHO have estimated 3096 road traffic fatalities, at an estimated rate of 14.6 per 100,000 population in Sri Lanka in the year 2016 [7]. Also, as stated by the National Council for Road Safety Statistics, Ministry of Transport and Civil Aviation, at the Symposium on 'Achieving Sustainable Road Safety in Sri Lanka', over 3,000 road traffic deaths and over 35,000 road traffic accidents have been reported in the year 2018 only [8]. Out of the many causes of road traffic accidents globally, distracted driving has been identified as one of the leading causes of road accidents [11]. Generally known, sleepiness/drowsiness and fatigue can be considered as one of the common and unintentional reasons for the distraction of a driver.

The project is proposed to evaluate these factors and focus on addressing a method to detect a driver's sleepiness or drowsiness at the initial stages. The main objective is to monitor the eye movements to trace the driver's sleepiness at this stage and to warn the driver when not in a state to drive. Also, the next objective is to inform a close contact of a driver about the driver's exact location. Hence the overall objective is to minimize the road accidents caused by sleepiness in drivers, and in critical conditions, minimize the damage likely to be caused in such situations.

RELATED WORK

Research had been conducted to find a relationship between drowsiness measures and impairing driving performance. During the study, physiological factors such as eye state, and eye closure have been found to be of high accuracy when predicting sleepiness [10].

Eskandarian & Mortazavi have researched to evaluate an algorithm to detect drowsiness and have used an experiment conducted in a simulator laboratory, involving truck drivers [5] Driver state had been analyzed using 2 methods: Subjective Drowsiness Rating (SDR) and Eye Closure Measure (PERCLOS).

A driver drowsiness detection system, to detect drowsiness by tracking the driver's face and eyes to measure the Percentage of eye closure was proposed [2]. The system had further been developed to trigger an alarm when drowsiness was detected.

A monitoring and Warning System had been developed also by detecting the face and eye detection [9]. The system was designed to trigger an alarm as well as to vibrate the driver's seat belt as an additional alert.

Another system was developed to conclude drowsiness and alert driver, to follow eye blink pattern analysis. The project was developed to use the Viola-Jones face detector on OpenCV, designed to locate the pupil hence blinking patterns, and then alert the driver using a voice message [3].

A research paper in 2016 explained real-time Monitoring and eye blinking detection. This system was designed to trigger a buzzer and a Vibration motor to alert the driver [1]

A program has been developed using MATLAB software to detect driver fatigue using a method of first detecting the eye state as whether open or close and then counting the frames of closed eyes to conclude whether the driver is fatigued and hence warn the driver [4].

Real-time drowsiness detection with the use of an analysis by an android application and alerting system was developed. The project introduced a solution to extract facial images using a mobile camera and passing datasets through an algorithm to detect drowsiness and send a visual and audio signal to alert the driver [6].

RESEARCH METHODOLOGY

For primary data gathering, the questionnaire method was used in the form of an online survey. A Google form was prepared with questions to cover all the required areas for the research. Nearly 200 responses were recorded, and all the respondents were valid driving license holders aged between 18-55.

The results of the survey indicated that almost 75% and almost 62% of the respondents had a connection to someone causing an accident due to sleepiness and a connection to someone being a victim of such an accident, respectively. The results are shown in Figure 1.

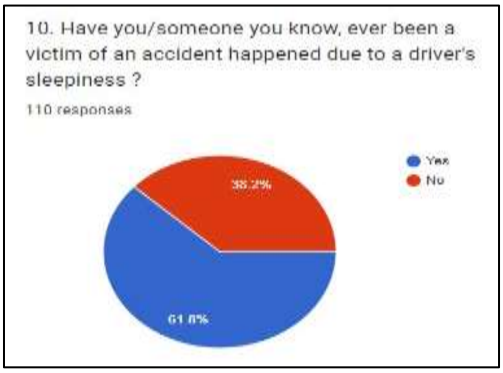

Figure 1 Survey response summary to accident connections

The survey also indicated how the general public would respond to an instance where they are required to drive after a tiring day or a sleepless night. More than 71% of the respondents (Almost 3/4 of the total respondents) have chosen the option to drive if the matter is urgent. As per these survey results, accidents caused due to sleepiness in drivers could clearly be stated as a critical problem. This is depicted in the pie chart in Figure 2.

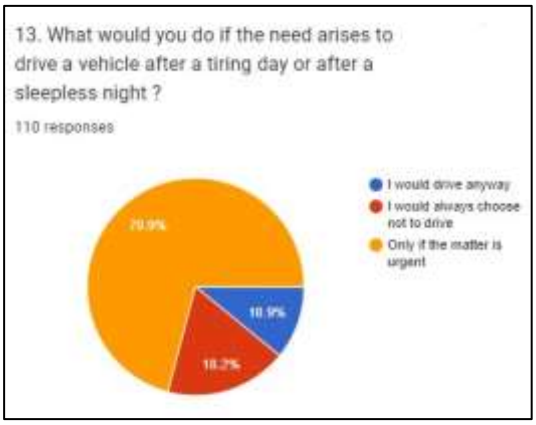

Figure 2 Survey response summary to driving after a tiring day

The flow diagram of the introduced system is shown in Figure 3. The Pi camera is used to trace the eye region of the driver continuously and depending on the parameter 'Eye Aspect Ratio', the system decides whether the driver is sleepy or not, and if the driver is detected as sleepy, the system triggers an alarm and simultaneously shares the current location of the driver to a closed contact (a pre-defined contact number).

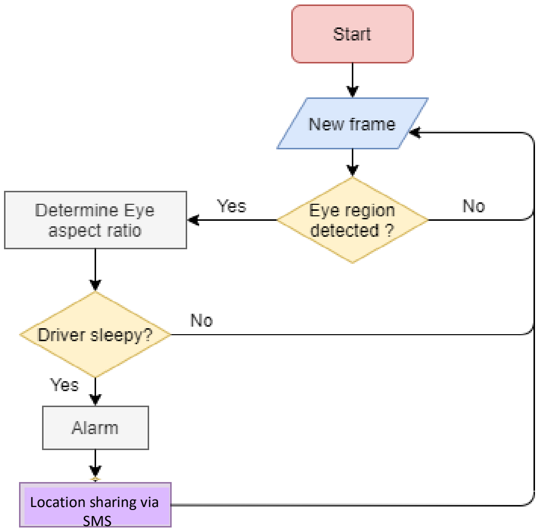

Figure 3 System Flow Diagram

The components used on the system are the Raspberry Pi 3B+ board, Pi camera, SIM808 module, and speaker. Figure 4 shows the block diagram of the system with the interconnected components. The raspberry pi acts as the motherboard and the controller of the system. The Pi camera is used to trace the driver's eyes while the SIM808 module is used for location tracking and SMS generating. A speaker is used for triggering the alarm. The unit is powered using an external power supply, for which the vehicle's auxiliary power outlet is used.

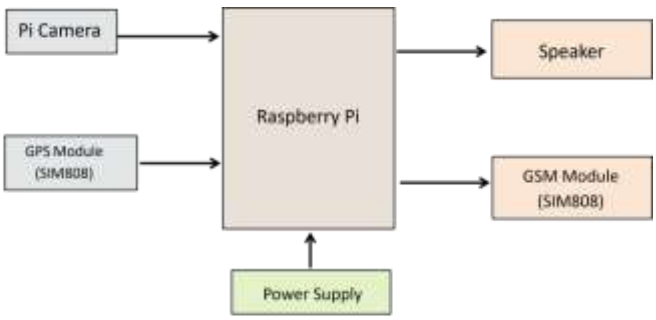

Figure 4 System Block Diagram

The system uses the concept of Eye Aspect Ratio (EAR) in determining the closure of the eye. The EAR-obtaining procedure is shown in Figure 5 and Equation (1).

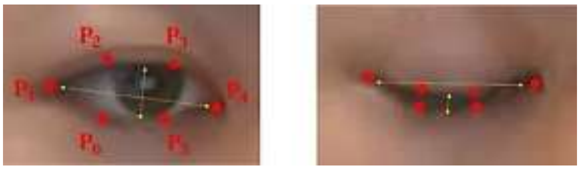

Figure 5 Eye Aspect Ratio Comparison

$$EAR = \frac{\|p_2 - p_6\| + \|p_3 - p_5\|}{2\|p_1 - p_4\|} \tag{1}$$

The system is programmed to analyze each of the frames on the input video stream captured by the Pi camera. In each frame, the Eye aspect ratio is calculated. The Eye aspect ratio (calculated using specific points on the eye edge) received in each frame is compared with a predefined threshold EAR value, and if the obtained value is below the threshold, the frame is counted as 1. The loop continues running the process for each frame and adding to the counter. And once the counter reaches a pre-defined count, the alarm is programmed to be triggered. This indicates that the eyes have been partially closed for a continuous number of frames. This number of frames is adjusted, based on the fps (frames per second) of the used camera. And as the alarm starts triggering, the SIM808 module activates, the current location is tracked, and then sends the location as a text message to the saved number.

The system consists of interconnected hardware components that are completely automated. The process is completely programmed using Python and the program is set to run automatically once power is supplied to the system, and Raspberry Pi is switched on. The input to the system is the video stream captured by the camera and the GPS location coordinates traced by the GPS antenna. The Interconnected system prototype is shown in Figure 6.

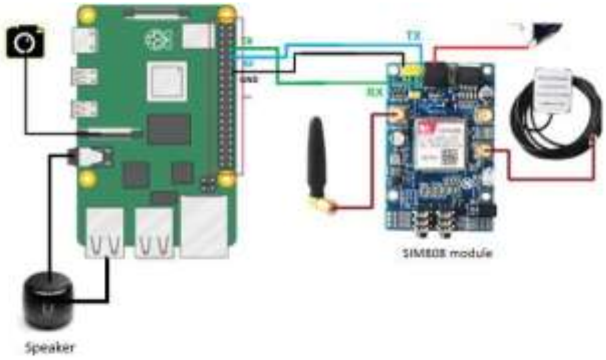

Figure 6 Interconnected system prototype

But in case the user requires to change the phone number of the location-sharing emergency contact, the board can be connected to a screen via HDMI, and the phone number can be changed on the already created text file, as shown in Figure 7.

Figure 7 Text file with emergency contact number

RESULTS AND DISCUSSION

The system was tested inside a vehicle, and power was supplied through a phone charger USB (Universal Serial Bus) cable connected to the auxiliary power outlet inside the vehicle. The connected prototype of the system is shown in Figure 8.

Figure 8 System prototype when fixed inside a vehicle

After a few seconds and milliseconds of eye closure, the SMS was received at the provided phone number. The received SMS format is shown in Figure 9.

Figure 9 SMS with location coordinates of the vehicle

Further, for best observation, a screen was also connected for experimental purposes, and to observe the working procedure, the test was again conducted inside a closed area. Figure 10 shows the process of Eye Aspect Ratio analysis and determining sleepiness.

The system was thereby confirmed to obtain the required results accurately and efficiently.

Figure 10 Determining sleepiness using Eye Aspect Ratio

The eye aspect ratio was calculated up to the 3rd decimal place therefore the data analysis of the system can be stated as accurate.

CONCLUSION

The overall goal of the project was to address the problem of rapidly increasing statistics of road accidents caused due to sleepiness/drowsiness or fatigue in drivers. The outcome presents a system to be fixed inside a vehicle consisting of the features to monitor the eye level of the driver continuously and as soon as a sleepiness/drowsiness is detected, an alarm is programmed to trigger. And further, the system continuously tracks the current location of the vehicle, and the tracked location is immediately shared as a Google map link via a text message to a pre-saved number, to notify a close contact about the driver's state and the location. Hence the project addresses the initial problem and contributes to minimizing the risk of accidents likely to be caused due to sleepiness in drivers.

DECLARATIONS

Study Limitations

As a major limitation, the system is only capable of alerting and notifying, but no prevention mechanism is included in the system. Therefore, the project can be referred to as a method that contributes to minimizing the accidents caused due to sleepiness, and not to avoid all such accidents completely.

Another limitation is that the system is not intelligent enough to decide which contact to inform at the time of the alert. Therefore, the contact number should be initiated before the system starts working. If the provided phone number happens to be unreachable, the text message would not be delivered at that time. Therefore, when initiating the phone number, it should be properly ensured that the specific number is reachable at any given instance.

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