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IoT-based Eyes Closure Alert System for Drowsy Driver

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ABSTRACT

Internet of Things (IoTs) is a technology that links objects and mechanisms to the Internet. IoT devices are deployed in a number of areas within the transportation sector, notably in security and surveillance. The ability to track driving behaviour on the road using IoT can improve driver safety and reduce traffic accidents. In this paper, a prototype system to detect a driver's drowsiness is proposed. In particular, a facial landmark is used to extract the eye region, the eye aspect ratio, and closure patterns. This system will audibly alert the driver and invoke third party notification if drowsiness of the driver is detected. Through this system, traffic accidents caused by drowsy drivers can be avoided and driving behaviour can be evaluated by relevant personnel or employers.

Keywords: IoT in transportation, drowsiness, eye closure, alert system

INTRODUCTION

Technology has a huge impact on our society. It improves productivity in healthcare, transportation, entertainment and many more (Birkel & Hartmann, 2019). One of the examples of technology is Internet of Things (IoTs). Nowadays, the demand for internet application developments is very high. IoT, also known as the Internet of Everything (IoE), is bringing massive evolutionary changes in information and communication technology (ICT) by integrating wireless communications, sensors, and data processing techniques. In almost all segments of society and business, IoT has established new ICT dimensions which expect to improve quality of life, create new business opportunities, and improve the productivity of factories, buildings, public infrastructure and services (Khan & Yuce, 2019).

IoT has the potential to bring together the major technical and business trends of mobility, and data analytics. The data collected from physical objects through the use of embedded sensors can be analyzed by transportation authorities to increase safety. For instance, an accident caused by sleepy driving behaviour can be prevented. According to a report, a significant number of road accidents occur due to sleepy driving, resulting in severe injuries and fatalities (Preidt, 2018). For this reason, various studies have been carried out on the design of systems that can monitor driver fatigue and alert the driver in advance, preventing him from falling asleep behind the wheel and causing an accident.

Many traditional approaches have used vehicle-based metrics to model or detect driver behaviour. However, such indicators are highly influenced by the configuration of the road, the type of vehicles, and driver skills. Other approaches used psychological measures for their system, which tend to improve the monitoring accuracy of driver sleepiness. Nevertheless, these procedures are typically invasive, since electrodes must be placed on the head and body. Furthermore, there are few existing studies in which subjective measurements are used as inputs for the system, but these methods can distract the driver and lead to an ambiguous result (Hossain, 2018).

In view of this, in this paper, we proposed to design and develop a system that can detect eye drowsiness of a driver and alert him or a third party (such as an employer) accordingly. The proposed prototype system alerts the user when drowsiness is detected through audio indication and at the same time notifies the third party. In this way, the driver's behaviour can be recorded and the performance of the driving behaviour can be evaluated.

LITERATURE REVIEW

Bakar (2018) proposed a system to detect drowsiness with the notification of the accident and the location by using Global Positioning System (GPS) navigation. In this system, an evaluation of eye blinking using image processing technique through open source Computer Vision (OpenCV) is used to monitor eye condition. This system notes the duration that the eyes remain closed. If the driver is detected with closed eyes for about more than 4 seconds, the driver will be considered drowsy and an alarm system will be activated to warn the driver; at the same time, the status and location of the driver will be notified via SMS to another party (e.g. family members) for further action. A smartphone camera is also attached in front of the driver and used as a sensor to capture video.

According to the work of Rosebrock (2017), if the eyes have been closed for a sufficiently long time, an alarm will be triggered to wake up the driver. This system applies a computing metric called eye aspect ratio (EAR) that is unlike the traditional image processing method for computing blinks. This method involved simple calculation based on the ratio of distances between facial landmarks of the eyes.

Subbarao (2019) proposed to use an infrared (IR) sensor to detect the eye blink of the driver. The difference across the eye will be studied as per eye blink. The output indicates high if the driver's eyes are closed or else the output will indicate as low, signifying the closing or opening position of an eye. The IR outputs will trigger the alarm. The controller will send a warning signal so that it will display on a screen. The buzzer, which is placed near the driver, will be activated and alert the driver if he falls asleep during driving. The alcohol sensor is also used to detect whether the driver is drunk. Light and tilt sensors are also installed to detect whether the vehicle has had an accident. A summary of comparisons of the abovementioned works is shown in Table 1.

Table 1. Comparisons between existing systems.

		Bakar (2018)	Rosebrock (2017)	Subbarao (2019)
Platform		Intel Edison Board	Standard Laptop	LPC 2148 microcontroller
Efficiency/ Resource	Power consumption	Moderate	Low	Moderate
	Cost	Moderate	Low	High
Type of Connection	Wi-Fi	✓	×	✓
	Bluetooth	×	×	×
	Wired USB	×		×
GPS		✓	×	✓
GSM		✓	×	✓
Sound Feedback		✓	✓	✓
LCD		✓	✓ (laptop)	✓
LED		✓	×	✓

TOOLS & METHODS

In our work, we used the Rapid Application Development process (RAD) as shown in Figure 1, to conduct our project as it is suitable for the short time frame given for the proposed system.

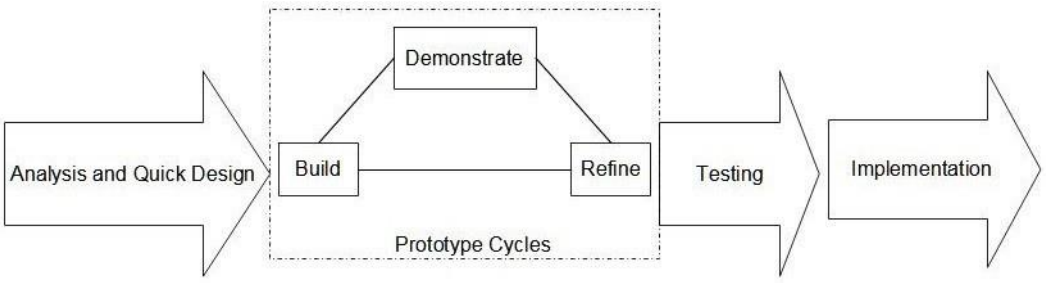

Figure 1. Rapid Application Development (RAD) model.

In order to apply the RAD model for the proposed system, we first conducted the following requirements analysis:

1. Identify User

The target user for this proposed system is the driver who has to travel on a long journey, any worker, and all types of drivers. This system can help them to stay alert while driving and allow a third party to be notified if driver drowsiness is detected.

2. Identify Requirements

The system requirements of the proposed system will be categorised into hardware and software requirements analysis. The following depicts each of the requirements:

i. Hardware Requirement

The hardware requirement will consist of a microcontroller, sensors and module. Table 2 shows the hardware requirement for the proposed system.

Table 2. Hardware requirement prototype.

Hardware	Name	Description
Microcontroller	Raspberry Pi	Raspberry Pi 3 B+ is a tiny computer board that when combined with CPU, GPU, USB ports, I/O pins, WiFi, Bluetooth, USB and network boot, is capable to perform some functions like a regular computer.
Sensors	Camera module for Raspberry Pi	A portable light weight camera that supports Raspberry Pi. It communicates with Pi using the MIPI camera serial interface protocol. It is normally used in image processing, machine learning or in surveillance projects.
Others	LCD	The Raspberry Pi 3 B+ display is an LCD display which connects to the Raspberry Pi through the HDMI cable.

ii. Software Requirement

The software requirement for the prototype of the proposed system is shown in Table 3.

Table 3. Software requirement prototype.

Software	Name	Description
Programming Software	Thonny Python IDE	It is a platform application to write and compile codes. It is an open source software that can be downloaded into Windows, Mac OS and Linux. This software provides Python language.
Operating System	Run in Windows, Mac OS and Linux	Operating system (OS) is a system software that manages computer hardware, software resources, and provides common services for computer programs.
Programming Language	Python	Python is an interpretive, object-oriented, high-level programming language with complex semantics. Its high level built-in data structures, combined with dynamic typing and dynamic binding, make it very attractive for Rapid Application Development.
Android Application	Pushbullet	Pushbullet is an extension and software that is available for Linux, iOS, Chrome, Firefox, Safari, Opera, and Windows. Pushbullet connects the phone with the PC and allows the phone to receive messages from the microcontroller.

Figure 2 shows the general system architecture of the proposed system. The architecture includes the hardware, the user, the third party, and sound feedback. The hardware and sensor will collect data from the user and if drowsiness is detected, a sound feedback will be produced. After that, the third party will be notified by the notification included with the time driver drowsiness is detected.

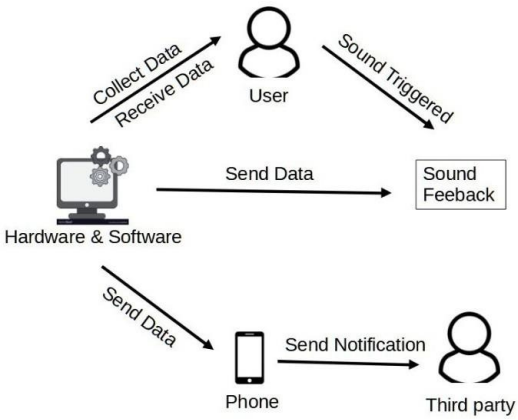

Figure 2. General system architecture of proposed system.

A general flowchart of the proposed system flow is shown in Figure 3. The system will start to detect the driver's face; if successful, it will proceed to detect the eye region and determine whether the eyes are open or not. If eyes are open, the process is repeated. If the eyes remain close for more than 2 seconds, a sound feedback will be produced and the third party will receive the relevant notification together with location of the driver.

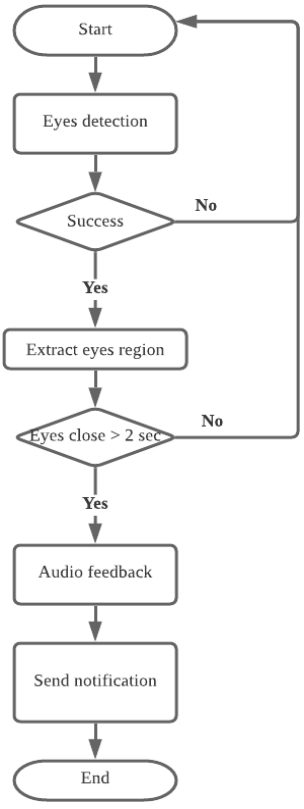

Figure 3. Flowchart of proposed system.

RESULTS

The alert system for detecting driver drowsiness through the study of eye closure has been successfully developed. We show here two test cases conducted for our testing. We show the test result in Tables 4 and 5 for Raspberry Pi and Pi camera, respectively.

Table 4. Test case for Raspberry Pi.

Test Case Name	Raspberry Pi 3 B+		
Test Case Description	1. To evaluate the Python IDE system is working completely. 2. To ensure that the Raspberry Pi 3 B+ is fully working.		
Pre-Condition	1. Raspberry Pi 3 B+ needs to be connected to the power source. 2. Connect Raspberry Pi 3 B+ with display monitor using HDMI cable. 3. Raspberry Pi 3 B+ is able to boot OS from SD card.		
Steps	Test Description	Expected Result	Result
1	Connect the Raspberry Pi to a power supply.	The LED of Raspberry Pi will light up.	Pass
2	Connect Raspberry Pi with display monitor.	The display shows Arduino IDE can be run.	Pass
3	Insert SD card into SD card slot in Raspberry Pi.	Able to boot OS from SD card. The display monitor will show the Raspberry logo and the home of Raspberry Pi displays.	Pass

Table 5. Test case for Pi camera.

Test Case Name	Pi camera		
Test Case Description	1. To test that the camera can be used to capture the image. 2. To ensure that the camera can detect changes in driver's eye closure. 3. To ensure that drowsiness can be detected.		
Pre-Condition	1. The Pi camera is connected well to the Raspberry Pi 3 B+ in Pi camera slot. 2. The Pi camera is connected and completely working with the Raspberry Pi 3 B+ board.		
Steps	Test Description	Expected Result	Result
1	Connect the Pi camera into the Pi camera slot in the Raspberry Pi board.	The LED on the Pi camera will light up.	Pass
2	Test the Pi camera to capture image and stream video.	The images are captured and the video is able to be recorded.	Pass
3	Test that the Pi camera can work well with the Python language.	The camera is able to detect the changes in size of the driver's eyes.	Pass

LIMITATIONS

There exist several limitations in this project. As the current prototype uses the Pushbullet application to send notifications, stable internet connection and accessibility is required for proper functioning. However, with the emergence of cloud technology, we believe this limitation will not be an issue in the near future.

Camera resolution is an important factor in this project which will affect the output of the proposed system. At the current stage, due to the limited accessibility of the hardware we used, the Pi camera that we used has a low resolution. This may result in poor image quality and cause inaccurate detection.

Due to the limit of space and hardware, this prototype was tested in-house. The GPS Neo 6 cannot operate at optimal levels due to various physical interferences, such as the building's ceiling, which may prevent the GPS to obtain satellite signals.

CONCLUSION

The current prototype system can detect the driver's eyes and changes in eye size as a sign of drowsiness. The prototype is able to alert the driver or a third party if drowsiness is detected. In general, the objectives mentioned have been achieved and several limitations have been identified. With the proposed prototype, we hold that the system can be improved over time and has potential as a commercial product in the future.

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