THE DRIVER DROWSINESS DETECTION AND ALERT SYSTEM USING INTERNET OF THINGS (IOT) TECHNOLOGY

Qurrotul Aini[1],Jehad A.H Hammad[2]
[1]Dept. of Information Systems, UIN Syarif Hidayatullah Jakarta, Indonesia
[2]Department of Computer Information Systems Al-Quds Open University, Palestine

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ABSTRACT
The objectives of this study are to: 1) investigate the use of Internet of Things technology in driver drowsiness detection and warning systems; 2) design and develop such systems employing Internet of Things technology; and 3) test and assess the effectiveness of such systems. The created system, which is composed of hardware and software, uses an ESP32-CAM camera coupled to a cloud computing system to analyze and identify tiredness from the driver's behavior, including blinking and glancing away from the road. The device will alert users via speakers and a smartphone app that displays rest areas in the area when it senses tiredness. With a reaction time of under 0.5 seconds and an accuracy of 92% in identifying blinking and tiredness, the system's performance test demonstrated its ability to reliably detect driver drowsiness. For precise rest stop recommendations, the system may also establish a GPS connection. The results of the tests demonstrate that the system can function well in real time and successfully lower the chance of accidents brought on by fatigue.
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1. INTRODUCTION

With around 1.35 million deaths from traffic accidents annually, road safety is a major public health problem and a critical worldwide issue [1], [2]. Effective road safety management techniques are essential and have drawn interest from a variety of industries due to the significant losses in property and life caused by traffic accidents. Driver behavior, especially fatigue and distractions, is often blamed for most accidents [3]. These factors directly affect decision-making and response times, increasing the possibility of crashes or losing control of the vehicle. One of the most important issues influencing road safety is drowsy driving [3], particularly when driving long distances, at night, or when a driver is feeling tired. Despite the implementation of preventative measures, such as required rest breaks during travel, many drivers continue to be at risk for accidents caused by tiredness. As a result, devices that can identify and notify drivers when they exhibit symptoms of sleepiness have been developed [4]. Motion sensors that track head movements are one of the emerging technologies. and eyelid closure [5, 6], in addition to real-time eye movement monitoring systems [7], which assess driving behavior and send out alerts when they identify possible collision hazards. Methods for improving driving safety are constantly changing as a result of technology, especially when it comes to combining artificial intelligence (AI) and Internet of Things (IoT) technologies [8],

[4]. These sophisticated algorithms are able to precisely determine the likelihood of an accident, track driver behavior, and examine eye movements [3]. Eye-tracking sensors with cameras are essential for improving traffic safety. By using IoT and AI, these technologies are able to study driver behavior in real time and identify indicators of inattention or tiredness. The system may provide visual or verbal warnings when it detects unsafe conduct, which lowers the chance of accidents and enhances driving performance in general [9], [10]. Therefore, reducing traffic accidents and improving road safety depend on the study and development of efficient sleepiness detection systems. These developments not only safeguard drivers and other road users by reducing the likelihood of accidents, but they also provide a crucial basis for the creation of more sophisticated vehicle safety systems in the future.

2. LITERATURE REVIEW

2.1 DrowsinessDetection

One of the most important aspects of maintaining road safety is identifying driver sleepiness. There are two main methods: Contact methods assess physiological data including heart rate and electroencephalogram (EEG) readings using sensors.

Despite their excellent accuracy, these techniques are often expensive and impractical for real-world applications. Non-Contact Methods: These methods assess driving behavior using cameras and face recognition technologies. However, the accuracy and processing delays of these approaches are limited.

♣ Multiple technologies are now being integrated to produce sleepiness detection systems, including driving behavior characteristics like head position and blink rate as well as eye-based data like electrooculogram (EOG) signals. The goal of this integration is to increase accuracy and get over the drawbacks of using separate approaches. Given that tiredness is a contributing factor in 20–30% of traffic accidents globally, creating a system that is highly accurate, non-intrusive, and useful is still a top priority [4].DriverFatigueAlert Technologies

Driver tiredness detection technologies fall into a number of categories. The first group includes camera-based monitoring, which keeps tabs on variables including head posture, yawning, pupil movement, and other relevant elements. Voice recognition is another area that uses variations in speech patterns to determine how tired a person is. 1) ECG and EEG are important methods for detecting tiredness. 3) Steering Wheel Movement (SWM), 2) Local Binary Pattern (LBP), and 4) Optical Detection [11]

2.2 IntelligentVehicleSurveillance Systems

Technologies for vehicle surveillance have been created to improve road safety by using computer processing and real-time sensor data. The Tire Pressure Monitoring System (TPMS) is a crucial piece of technology that lowers the hazards connected to excessive tire pressure. Road condition assessment devices are also capable of identifying dangers like potholes and slick surfaces.

In order to make real-time modifications in emergency circumstances, driver-assistance technologies, such autonomous braking systems and stability control systems, employ sensors and cameras to monitor driving behavior and environmental variables. The Smart Mobility concept, which links data to improve safety and lower accident rates, often incorporates these technologies. On-Board Diagnostics (OBD-II) data, such as tire pressure, fluid temperature, and engine condition, are analyzed using machine learning (ML) and

used in vehicle monitoring models. Predictive maintenance is made possible by this, guaranteeing peak vehicle performance and proactive problem solving [12].

2.3 RelatedResearch

In 2024, Dr. B. Saroja, Ph.D., and colleagues [17]. created a sleepiness monitoring system for public transportation and logistics using the Internet of Things. This system uses computer vision methods and driving behavior analysis to identify distractions, yawning, tiredness, and sleepiness. Through proactive driver behavior management, it improves road safety by integrating cloud modules, edge computing, embedded devices, and a mobile application for real-time monitoring. [13] Ghole Uzair et al. (2020). suggested a technique for detecting tiredness in four-wheel drive automobiles in order to improve driver safety. The device uses a USB camera to take pictures of the user's face and eyes for tiredness analysis, and it sends out notifications to avoid mishaps caused by sleepiness. In order to provide a thorough safety approach, it employs image processing algorithms to identify sleepiness, sound an alert, and transmit emergency messages via cloud platforms.
Sangharsh Shinde and Ashwini Araballi (2023) [14]. launched a real-time sleepiness monitoring system that measures driver weariness using the Mouth Opening Ratio (MOR) and Eye Aspect Ratio (EAR). The device, which uses a Raspberry Pi and a Pi Camera, continually examines patterns of mouth opening and eye closure to detect tiredness. When it detects anything, it sounds an alarm to warn the driver, lowering the chance of an accident and enhancing traffic safety. Malini S. and Duraimurugan M. (2024). [15] Using a Python-based camera system, a Driver Sleep Monitoring System (DSMS) was created to monitor driver alertness constantly and identify tiredness, a serious risk to road safety. The device analyzes facial characteristics using computer vision algorithms and takes pictures in real time to spot signs of weariness including extended eye closure and altered head movements. Dey, Moumita, and others (2024). [16] created a system to detect indicators of sleepiness in drivers by tracking their behavior. It evaluates driver attention by tracking eye movements, blinking patterns, and facial features using sophisticated algorithms. The device identifies whether a motorist is feeling sleepy by precisely assessing their condition.

3. RESEARCHMETHODOLOGY

Thisresearchwas conductedthrough thefollowingsteps:

3.1 LiteratureReview

3.1.1 Examine theories and earlier studies of Internet of Things-based driver sleepiness monitoring systems.
3.1.2 Examine the technologies used to identify eye movements, blinking patterns, and gaze diversion from the road, among other driver behavior indicators.
3.1.3 Look into appropriate sensors and equipment for the monitoring system, such as Internet of Things-based gadgets and eye-tracking cameras.

3.2 SystemDesign andDevelopment

3.2.1 Designthesystemarchitecturebydefiningkeycomponents,including

hardware, software, and processing systems.

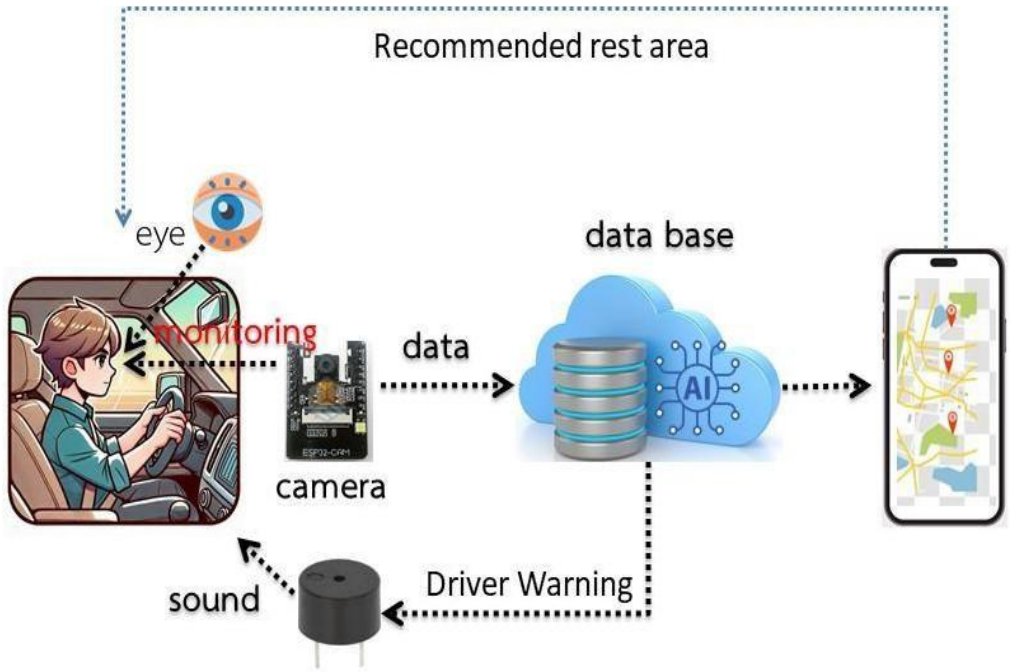

Figure1.Overallsystemoperation.

FromFigure1Theoverallsystemoperation.Thecamerafunctionsasanimagecap
ture
device,specificallydetectingthedriver'seyesandtransmittingthevisualdatatoacloud-based processing unit. The artificial intelligence (AI) system then analyzes the received eye images to determine whether they exhibit signs of drowsiness.

The event is logged as one occasion if the AI system senses tiredness. The device initiates an alarm mechanism when it detects three occurrences of sleepiness in a succession. A speaker receives the signal and plays an auditory warning to raise driver awareness. In order to guarantee safe driving practices, the smartphone application simultaneously launches a navigation interface that shows a map directing the motorist to the closest rest area.

The system's capabilities are divided into two main components: Hardware and Software, with the details as follows:

Hardwarepart

Thehardwarecomponentisdesignedbytheresearchers,asillustratedinFigure2.

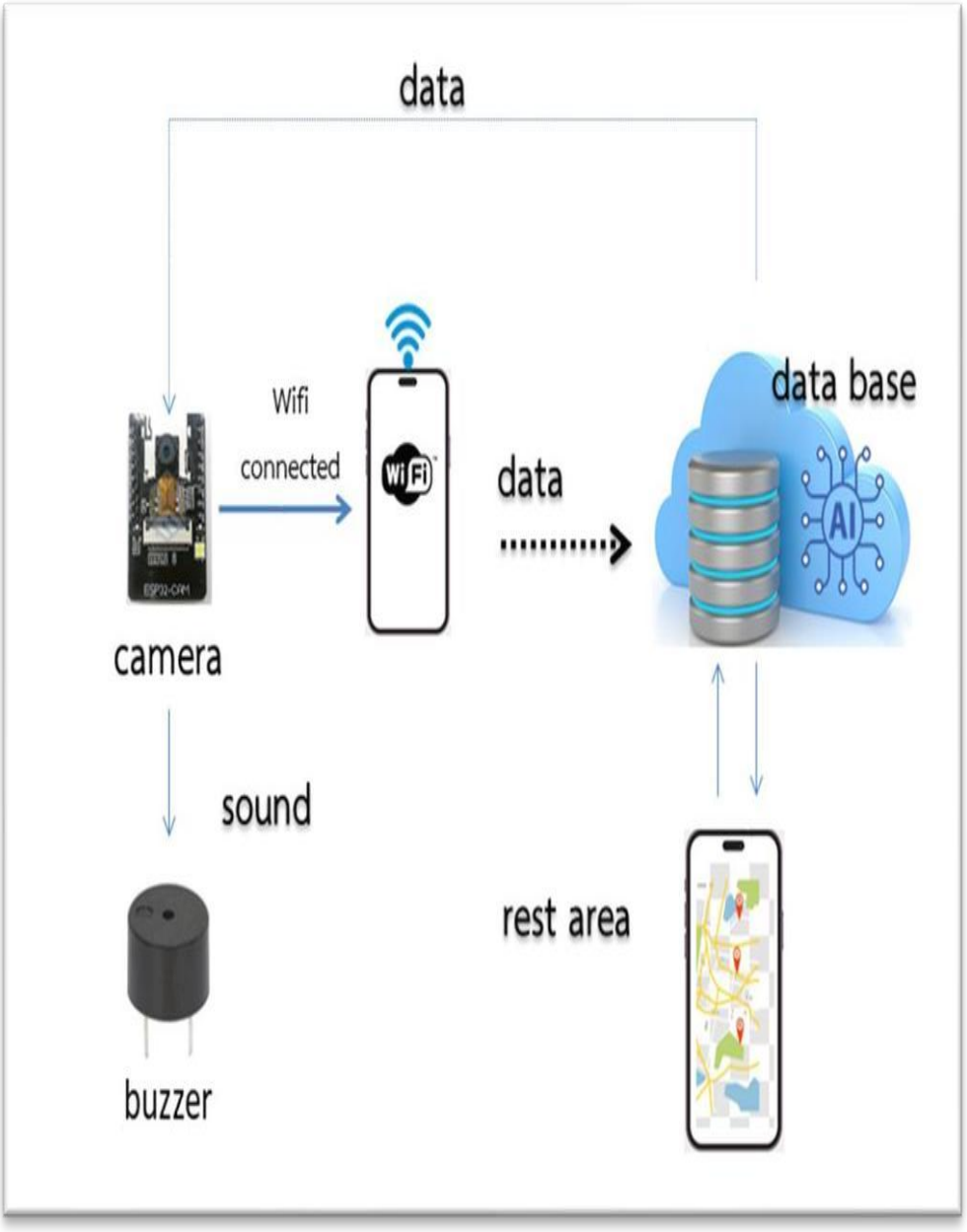

Figure2.Overallhardwarecomponent.

FromFigure2,the systemoperates throughthefollowing steps:
1) The driver's blinking behavior is continually observed by the ESP32-CAM. 2) The smartphone serves as a hotspot for Wi-Fi. 3) The user's smartphone's Wi-Fi signal is used to connect the ESP32-CAM to the internet. 4) To determine the driver's level of tiredness or eye deviation, the ESP32-CAM sends eye movement pictures via Wi-Fi, which are then saved and analyzed on a cloud computing platform utilizing artificial intelligence technology.
5) In the event that the system detects sleepiness, it signals the ESP32-CAM to turn on the speaker, providing the driver with an audio alarm. 6) The smartphone app launches immediately to show the motorist the rest locations that are close by.
Softwarepart

Thesoftwareoperationis designedbytheresearcher, asillustratedinFigure3.

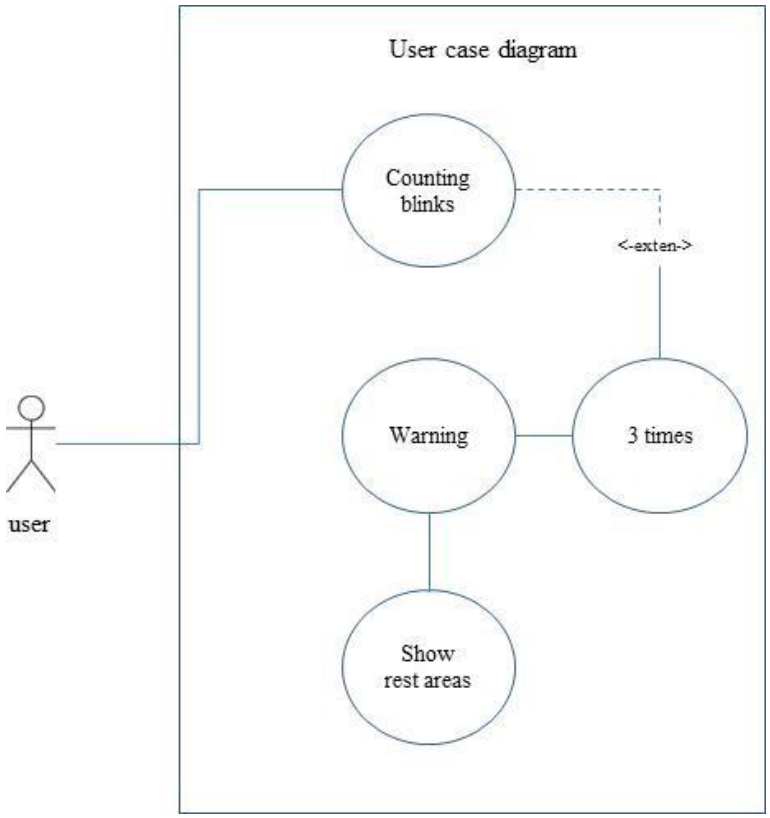

Figure3. UseCaseDiagram.

FromFigure3,the softwarecomponent operatesasfollows:

1) Userscanregister forsystem access.
2) Thesystemperformsauthenticationbeforeallowing access.
3) ThesystemcandisplaythenearestrestareasviatheapplicationusingGPSnavigation.
4) Thesystemcanimmediatelynotifythedriverthroughvoicealertsfromtheapplica tion, ensuring real-time information delivery.

3.3 SystemImplementationand Testing

3.3.1 Set up the test system on a mock car and adjust how the gadget works.

3.3.2 Assess the system's functionality in real-time situations.

3.3.3 Evaluate the accuracy of the system by contrasting the real driving circumstances with the detected sleepiness signals.

3.4 SystemImprovementandOptimization

3.4.1 Analyzeerrors andrefine thesystem’sefficiencybasedontestresults.

3.4.2 Enhancetheprocessingalgorithmtoimprovetheaccuracyofdrowsiness

detection.

3.5 Conclusion andDocumentation

3.5.1 Examine the outcomes of the experiment and highlight the main conclusions. 3.5.2 Write the study report and provide suggestions for next system advancements. This methodical methodology guarantees a thorough investigation of the sleepiness detection system, integrating real-time analysis, machine learning, and Internet of Things technologies for improved driver safety. Please let me know if you need any changes.

4. RESULT

Thisstudy yielded thefollowing findings:

4.1. Study Results on Driver Drowsiness Detection and Alert System Using Internet of Things Technology

According to a research on driver drowsiness detection and alert systems, drowsiness detection and alerting solutions may be developed using Internet of Things (IoT) technology. A communication platform for providing alarms via cellphones or audio devices, real-time data processing equipment, and sensors for tracking driver behavior make up the system under study. The study's analysis of detection techniques shows that eye-tracking sensors and blinking behavior monitoring are reliable ways to measure tiredness. Furthermore, the accuracy of sleepiness detection is improved by using artificial intelligence (AI) to evaluate data from cameras and sensors.

4.2. Design and Development Results of the Driver Drowsiness Detection and Alert System Using Internet of Things Technology

The designed and developed system consists of two main components: hardware and software.

Hardwarepart

Theresearch findings on thehardwarepart areshownin Figure4.

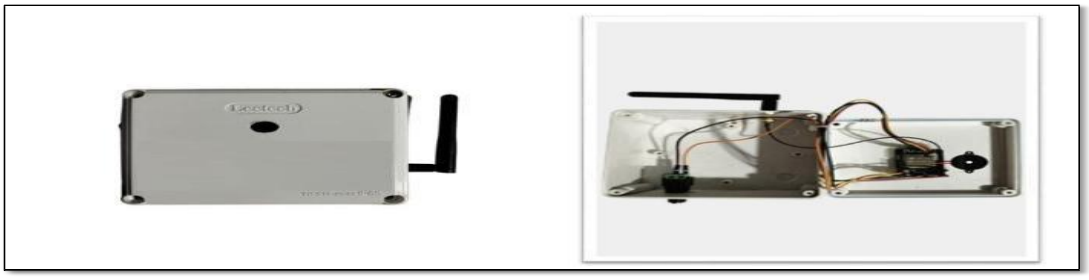

Figure4. Hardwarepart.

From Figure4, the system consists of:

1) Controlling the detecting system using the ESP32S board acting as the primary CPU.
2) Setting up a camera to identify eye traits and use AI to interpret the information.
3) The capability of using a speaker to emit alarm sounds when sleepiness is detected. Section on Software

TheresearchresultsforthesoftwareareshowninFigures 5–6.

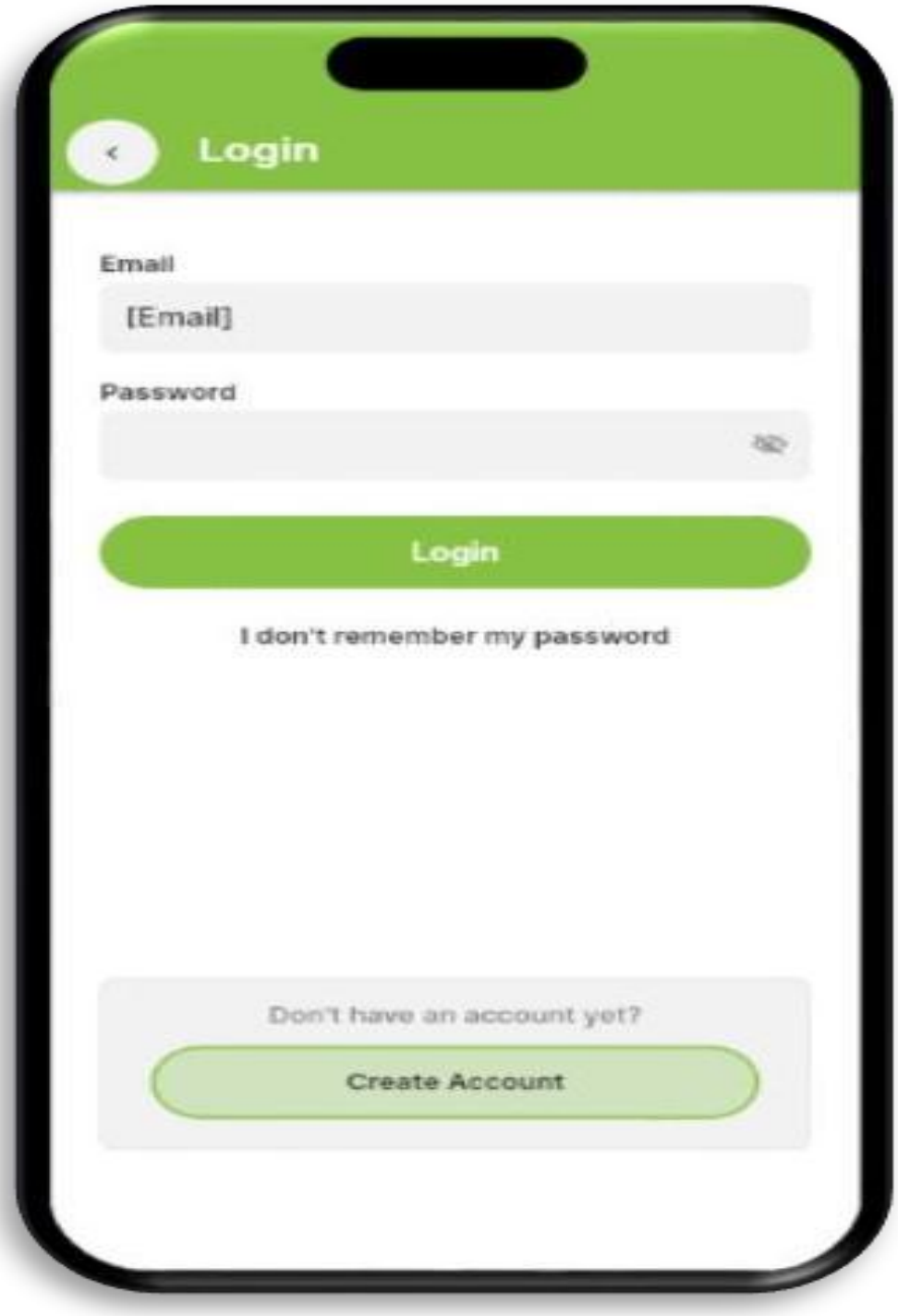

Figure5. Registrationscreen section

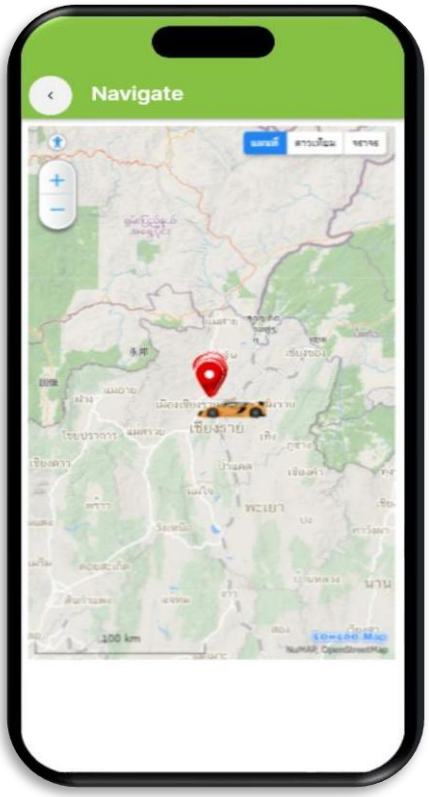

Figure6. Servicelocationdisplayscreensection

BasedonFigures5and6,theresearchfindingsregardingthesoftwarecomponents include:

1) Creation of an application for identification verification and driving registration.

2) A smartphone may be used by the system to track the user's whereabouts.

3) The app may show the locations of rest areas that are close by.

4) To assist prevent accidents brought on by tiredness, the system was designed to function in real-time, using quick processing from IoT devices and precise alerts.

4.3 Test Results and Performance Evaluation of the Driver Drowsiness Detection and Alert System Using the Internet of Things (IoT) Technology

Thetestresultsshowthatthesystemcanaccuratelydetectthedriver'sdrowsiness, with the ability to clearly distinguish between drowsiness and normal blinking.HardwareTestResults

Thetest results forthe hardwareareshown in Table1.

Table1.HardwareTestResults

TestItem	TestResultDescription	Performance Value
1.AccuracyofEyeDetection and Blinking Behavior	Thesystemcanaccuratelydetectblinking and drowsiness, clearly distinguishing between normal blinkingand drowsiness.	92%
2.ResponseTimeofAlert System via Speaker	The alert system activates immediately afterdetectingdrowsinessandnotifiesthe drivereffectively.	0.5 seconds
3.ClarityofCameraImagefor Eye Detection	Thecamerausedfordetectioncancapture clearimagesofthedriver'sfaceandeyes under various lighting conditions.	Clearunder normalandlow light
4. Performance of Head MovementDetectionSensor	The system can detect head movements, suchasnoddingorheadtilting,whichare signsof drowsiness.	90% accurate
5.SystemStabilityduring Continuous Operation	The system can operate continuously for longperiodswithoutissuesofoverheating or malfunction.	Stablefor8 hours continuous operation

SoftwareTest Results

Thetest results forthe softwareareshown in Table2.

Table2. SoftwareTestResults

TestItem	TestResultDescription	Performance Value
1.ConvenienceofAccessing AlertSystemviaApplication	Userscanreceivealertsviathe application conveniently,quickly,andcancustomize the notifications as needed.	Easytouse
2. Accuracy of Location IdentificationandRestArea Display	ThesystemcanconnectwithGPStodetect the driver's location and accurately recommendthenearestrestarea.	Highly accurate
3.PerformanceofSmartphone Notification	Thesystemcansendnotificationsthrough smartphones and IoT devices effectively.	Immediate notifications
4.AbilitytoRecordand Display Historical Data	Thesystemcanrecordalertdataand drivingbehavior,allowinganalysisand improvement of driving habits.	Unlimiteddata storage
5.StabilityofConnection between Application and Hardware	The application can continuously connect withthecameraandsensorsofIoTdevices without disconnections.	Stable continuous connection 95%(depends on internet signal)

The system can correctly identify driver sleepiness and offer real-time notifications, according to the hardware and software test findings. While the software provides users with precise alerts and information, the hardware efficiently recognizes eye and head movements. This technology may be utilized in practice to improve road safety and successfully lower the number of drowsiness-related accidents.

5. SUMMARY

The Internet of Things (IoT)-based driver sleepiness detection and alarm system is made up of two components: software and hardware. These components work together. In tandem with the software, the hardware tracks the driver's blinking patterns and transmits the information to the cloud for processing. The hardware will play a sound on the speaker and launch an application that displays a map of nearby rest areas if the system determines that the driver is sleepy. This study examines how IoT technology may be used as a tool to assist lower the number of accidents caused by sleepy drivers.

6. CONCLUSIONS

The study's findings demonstrate how effectively IoT technologies and smartphone apps can monitor and alert drivers to signs of fatigue and assist avoid traffic accidents. This system is capable of continuous operation and instantaneous warning. Additionally, it operates in real time and has the ability to promptly alert drivers, decreasing the loss of life and property while also promoting safety for other people.

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