Section A-Research paper
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Enhancing Road Safety with an IoT-Enabled Smart Alert System for Detecting Drowsy Drivers

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Abstract

This research presents an IoT-enabled smart alert system for enhancing road safety by detecting drowsy drivers. Driver drowsiness is a significant contributor to road accidents, making it crucial to develop effective systems that can detect and mitigate this risk. The proposed system utilizes a combination of IoT technologies, including a Raspberry Pi camera, proximity sensors, a crash sensor, and GPS, to monitor driver behavior and respond to potential hazards. The system's application involves capturing high-quality images using the Raspberry Pi camera, which are then processed to detect the driver's eye movements and calculate the Eye Aspect Ratio (EAR) as an indicator of drowsiness. Proximity sensors are employed to detect obstacles and trigger alarms when the vehicle approaches them. Additionally, a crash sensor registers collision impacts based on vibrations, immediately transmitting the signal to the home mobile device and generating email alerts to inform relevant parties of the accident. In the laboratory setting, the system's performance was evaluated by recording EAR values over a 10-minute period, demonstrating its ability to accurately detect drowsiness. Furthermore, a collision scenario was created to assess the system's response and accuracy in detecting and notifying accidents. The obtained location data from the collision system proved valuable in promptly notifying the base location of the collision. The results of the performance analysis indicate positive outcomes in terms of true eye detection, alarm production, and email notifications. However, there were instances of false detections and notifications, emphasizing the need for further refinement and algorithm optimization. Overall, this IoT-based smart alert system holds significant potential for improving road safety by identifying drowsy drivers and responding to potential collisions. By leveraging IoT technologies, we can create smarter and safer transportation systems, reducing the risk of accidents caused by driver fatigue and enhancing overall road safety.

Keywords: *IoT, Driver drowsy, Camera, Sensor*

1. Introduction

Road safety is a critical concern worldwide, with a significant number of accidents and fatalities occurring due to various factors, including driver drowsiness. According to research studies, drowsiness significantly impairs a driver's alertness, reaction time, and decision-making abilities, leading to an increased risk of accidents on the roads. Detecting driver drowsiness in real-time is crucial for implementing preventive measures and improving road safety. In recent years, advancements in technology, specifically Internet of Things (IoT) and image processing techniques, have provided opportunities to develop smart alert systems capable of identifying drowsy drivers and preventing potential accidents [1], [2]. The objective of this research is to propose an IoT-enabled smart alert system for detecting drowsy drivers, thereby enhancing road safety. The system combines various components, including a Raspberry Pi camera, proximity sensors, a crash sensor, and GPS technology, to monitor driver behavior and respond to potential hazards [3]–[5]. The integration of these technologies allows for real-time monitoring of driver drowsiness, obstacle detection, and collision impact assessment.

Numerous studies have been conducted to explore different methods and technologies for detecting driver drowsiness. These approaches range from physiological measurements, such as tracking eye movements and brain activity, to behavioral indicators, such as steering wheel movements and lane deviation. Some studies have also utilized machine learning algorithms to analyze multiple data inputs and accurately identify drowsiness. While these approaches have shown promising results, they often require specialized equipment and may not be suitable for real-time monitoring in everyday driving scenarios [6]–[8].

The emergence of IoT has revolutionized road safety by enabling the development of smart alert systems. These systems leverage IoT technologies, including sensor networks, data analytics, and connectivity, to monitor driver behavior and environmental conditions. By integrating various sensors, such as cameras, proximity sensors, and crash sensors, with data processing capabilities, these systems can detect potential risks and alert drivers in real-time. Furthermore, they can transmit crucial information to relevant parties, such as emergency services and nearby vehicles, to prevent accidents and mitigate their consequences [9], [10].

Image processing techniques have been widely employed in driver drowsiness detection systems. These techniques involve capturing images or video footage of the driver's face and analyzing specific facial features, particularly eye movements and closures, to assess drowsiness levels. Common approaches include the calculation of the Eye Aspect Ratio (EAR) and the detection of characteristic patterns associated with drowsiness, such as slow eye blinking or eye closure duration. By employing machine learning algorithms, these systems can achieve high accuracy in detecting drowsiness based on visual cues [11]–[13].

In conclusion, the proposed research aims to leverage IoT and image processing techniques to develop an efficient and reliable smart alert system for detecting drowsy drivers and enhancing road safety. By combining various components and algorithms, the system will enable real-time monitoring of driver drowsiness, obstacle detection, and collision impact assessment. This research builds upon existing approaches and technologies in the field, with the objective of addressing limitations and improving the accuracy and effectiveness of drowsiness detection systems. By successfully implementing such a system, it is anticipated that the incidence of accidents caused by driver drowsiness can be significantly reduced, leading to safer road environments for all.

2. Methodology

The primary objective of this research is to develop an IoT-based system for identifying driver drowsiness. The system utilizes a Raspberry Pi camera capable of capturing high-quality images during mobile operation. The Raspberry Pi 3 is employed for data transfer and processing, facilitating efficient communication and analysis. To alert the driver in case of drowsiness, a speaker is incorporated into the system, which emits an alarm sound based on the detected level of drowsiness. In order to enhance road safety further, proximity sensors are installed both at the front and back of the vehicle. These sensors continuously monitor the distance between the vehicle and nearby obstacles. Whenever an obstacle is detected within a predefined range, the system triggers an alarm to alert the driver about the potential danger, thereby aiding in collision prevention.

To detect accidents or collisions, a crash sensor equipped with vibration detection capabilities is utilized. This sensor actively monitors the vehicle for sudden impacts or vibrations that indicate a crash. In the event of a crash, the system instantly sends a signal to the driver's home mobile device. Additionally, an email alert is generated to promptly inform relevant parties about the occurrence of the accident, enabling swift response and necessary assistance. The comprehensive system architecture, including the Raspberry Pi camera, Raspberry Pi 3, speaker, proximity sensors, and crash sensor, is depicted in Figure 1. This visual representation offers a clear understanding of the interconnections and setup of the various components within the system.

The methodology of this research begins with the process of drowsiness detection. The Raspberry Pi camera captures high-resolution images of the driver's face, which are then subjected to computer vision techniques. Through the analysis of facial landmarks and eye characteristics such as closure and blink frequency, the system determines the level of drowsiness exhibited by the driver. To enhance the accuracy and reliability of drowsiness detection, sophisticated machine learning algorithms like convolutional neural networks (CNNs) can be implemented, enabling more precise identification of drowsiness patterns. The alarm system plays a vital role in notifying drowsy drivers in real-time. By integrating a speaker into the system, an audible alarm is generated when signs of drowsiness are detected. This immediate auditory feedback serves as a timely reminder for drivers to remain attentive and focused on the road, effectively reducing the risks associated with driver fatigue.

The incorporation of proximity sensors adds an extra layer of safety to the proposed system. These sensors constantly monitor the proximity of the vehicle to surrounding objects, detecting potential collision hazards. When an object is detected within the predefined range, an alarm is triggered, instantly alerting the driver about the impending danger. This feature allows drivers to promptly respond and take necessary evasive actions, thus minimizing the likelihood of accidents. Furthermore, the crash sensor, with its vibration detection capabilities, ensures timely detection of accidents or collisions. By continuously monitoring the vehicle for sudden impacts or vibrations, the system can identify the occurrence of a crash. Upon detecting a crash, the system immediately transmits a signal to the driver's home mobile device, providing instant notification of the event. Additionally, an email alert is automatically generated to inform relevant parties about the accident, facilitating swift responses and the required assistance.

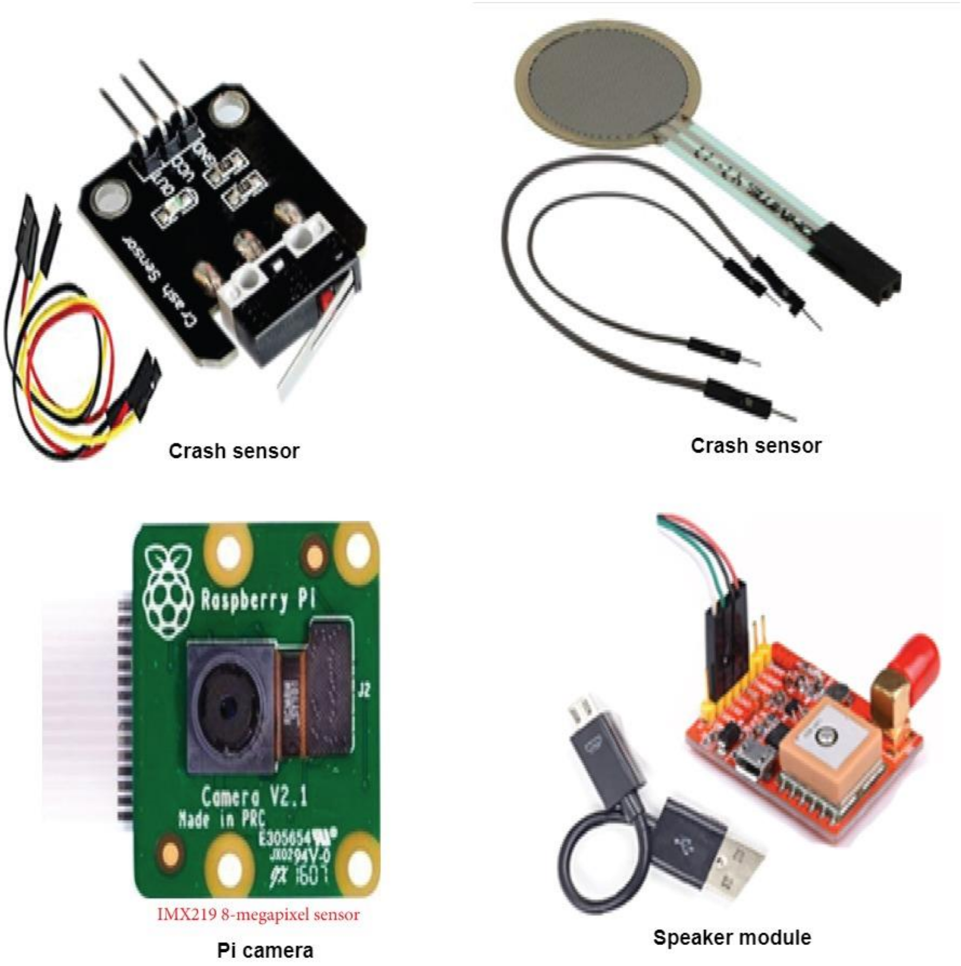

Fig.1 Various components used in this research

3. Working of the proposed system

The proposed system operates based on the Eye Aspect Ratio (EAR) and the Euclidean distance of the eye, which are key factors in determining the driver's level of drowsiness. The working principle involves several interconnected components that collectively contribute to enhancing road safety (Fig. 2). To begin with, the Pi camera plays a crucial role in detecting the blink of the eye and calculating the EAR value. By analyzing the facial landmarks and the spatial relationship between the eyes, the system can accurately determine the EAR value. A low EAR value indicates drowsiness, while a higher EAR value suggests that the driver is conscious and alert. This real-time monitoring of the driver's eyes enables timely detection of drowsiness.

In addition to drowsiness detection, the system incorporates proximity sensors that continuously monitor the distance between the vehicle and nearby objects. When the proximity sensor detects that the vehicle is approaching too close to an obstacle, it triggers an alarm. This serves as a warning to the driver, enabling them to take immediate evasive actions and prevent potential collisions. Furthermore, in conjunction with proximity sensors, the drowsiness detection mechanism also contributes to alerting the driver. If the EAR value indicates drowsiness, the system triggers an alarm, providing an audio alert to the driver. This dual-alert system, combining proximity sensors and drowsiness detection, ensures that drivers are promptly notified of potential dangers, whether they stem from external obstacles or their own drowsiness.

In the unfortunate event of an accident, the crash sensor comes into play. This sensor detects impacts or vibrations resulting from a crash. By monitoring sudden changes in forces, the crash sensor swiftly identifies accidents and triggers the system's response. To measure the force induced by various sensors, force sensing registers are strategically placed at different locations within the vehicle. These registers provide crucial data about the magnitude of the impact, aiding in assessing the severity of the accident. Additionally, the system incorporates a GPS module that transmits the location signal to an Arduino device. The Arduino, connected to the internet, plays a pivotal role in communicating alerts via email and storing the location information in the cloud. This allows for efficient and immediate communication of the accident to relevant parties, facilitating prompt responses and necessary assistance.

Moreover, the system features a speaker within the vehicle, which, in the event of an accident, emits an alarm to inform nearby individuals, such as neighbors, about the occurrence. This audio alert system ensures that immediate attention is drawn to the accident, potentially expediting the arrival of help.

OpenCV (Open Source Computer Vision Library) is a popular open-source computer vision and machine learning library that provides a comprehensive set of tools and algorithms for image and video processing, as well as object detection and recognition. Originally developed by Intel, OpenCV has become a widely adopted library in the field of computer vision due to its versatility, efficiency, and extensive documentation. OpenCV is written in C++ and offers interfaces for various programming languages, including Python, Java, and MATLAB. The Python interface, in particular, is widely used for its simplicity and ease of use. It provides a powerful yet intuitive API for developers to work with images, videos, and other computer vision tasks.

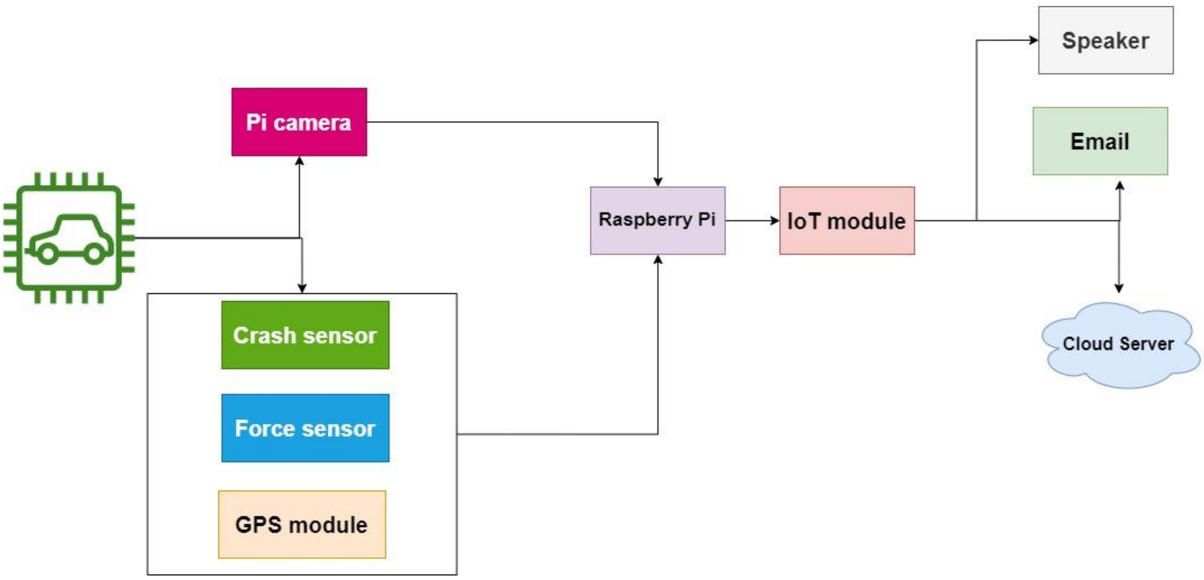

Fig. 2. Working of the proposed system

One of the fundamental features of OpenCV is its ability to handle image and video input/output operations. It supports a wide range of image and video formats, allowing developers to read and write image and video files effortlessly. This functionality is essential for processing video recordings in research applications, such as the one described in your research. For face detection, OpenCV offers a variety of algorithms and techniques. One commonly used approach is the Haar cascade classifier, which utilizes a set of trained classifiers to detect objects in an image or video stream. The Haar cascade classifier is particularly efficient in detecting objects with distinct visual patterns, making it suitable for face detection.

In addition to face detection, OpenCV provides functionalities for face recognition, facial landmark detection, and facial expression analysis. These features are essential for various computer vision applications, including biometrics, emotion recognition, and human-computer interaction. OpenCV also includes a wide range of image processing functions, such as image filtering, color space conversion, image enhancement, and geometric transformations. These operations enable researchers to preprocess images and videos, extract relevant features, and manipulate visual data according to their research needs.

Furthermore, OpenCV integrates machine learning capabilities, allowing developers to train and deploy custom models for various computer vision tasks. It provides support for popular machine learning frameworks like TensorFlow and PyTorch, enabling seamless integration of deep learning models into OpenCV pipelines. The library's community-driven development model has resulted in an extensive collection of documentation, tutorials, and code examples. The OpenCV community actively contributes to its continuous improvement, ensuring a robust and reliable toolset for computer vision research and development.

In the proposed research, the eye landmarks are identified and traced using the six coordinates obtained from face detection as shown in figure 3. These landmarks provide crucial information about the position and shape of the eyes. To calculate the EAR, the distances along the horizontal and vertical axes between specific eye landmarks are measured using the Euclidean distance equation. The Euclidean distance equation is derived from the Pythagorean theorem, which states that in a right-angled triangle, the square of the hypotenuse (the side opposite the right angle) is equal to the sum of the squares of the other two sides. In a two-dimensional space, the Euclidean distance between two points (x1, y1) and (x2, y2) is given by the following equation:

distance = sqrt((x2 - x1)^2 + (y2 - y1)^2)

To calculate the EAR, we need to determine the distances between specific eye landmarks. Let's denote the eye landmarks as follows:

Landmark 1: (x1, y1)

Landmark 2: (x2, y2)

Landmark 3: (x3, y3)

Landmark 4: (x4, y4)

Landmark 5: (x5, y5)

Landmark 6: (x6, y6)

The horizontal distance between Landmark 2 and Landmark 6 can be calculated using the Euclidean distance equation as:

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horizontal_distance = sqrt((x6 - x2)^2 + (y6 - y2)^2)

Similarly, the vertical distance between Landmark 4 and the average of Landmark 1 and Landmark 5 can be calculated as:

vertical_distance = sqrt((x4 - (x1 + x5)/2)^2 + (y4 - (y1 + y5)/2)^2)

Once the horizontal and vertical distances are obtained, the Eye Aspect Ratio (EAR) can be calculated as the ratio of the vertical distance to the horizontal distance:

EAR = vertical_distance / horizontal_distance

The EAR value provides a measure of the eye's openness, which is an important indicator of drowsiness. A lower EAR value suggests a higher likelihood of drowsiness, while a higher EAR value indicates that the eyes are more open and the driver is likely to be more alert. By applying the Euclidean distance equation and calculating the EAR based on the horizontal and vertical distances between eye landmarks, the proposed system can effectively identify and monitor driver drowsiness in real time.

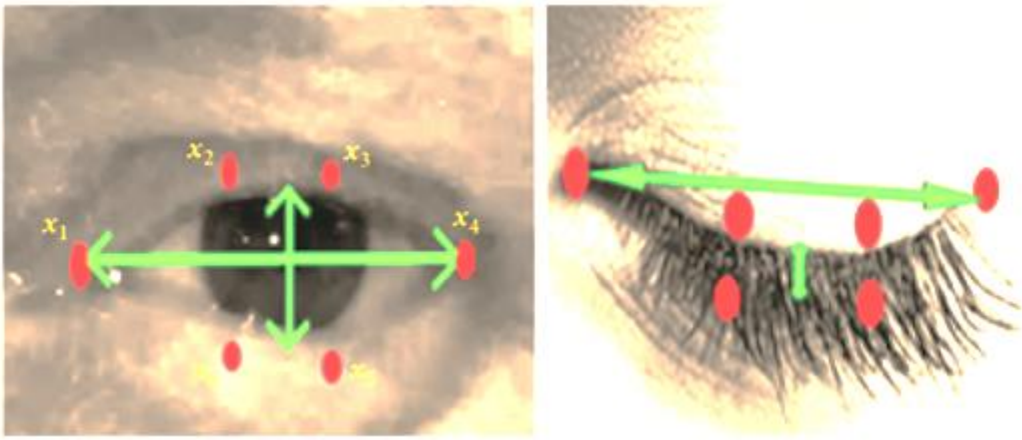

Fig. 3. Eye landmarks

4. Collision Detection

In the proposed research, the input from the crash sensor and force sensor plays a crucial role in registering the impact of a collision. These sensors are designed to detect sudden changes in forces and vibrations, allowing the system to promptly identify and respond to accidents. Once a collision or impact is detected, the system utilizes a Python script to collect data from various sensors within the vehicle. The Python script acts as an intermediary, receiving input signals from the crash sensor and force sensor, among others. These signals provide vital information about the magnitude and nature of the impact, helping to assess the severity of the accident.

After collecting the sensor data, the Python script proceeds to transfer the input to a local database. This local database serves as a repository for storing the recorded information related to collisions and impact forces. By storing the data locally, it ensures that crucial information is preserved and accessible for further analysis or investigation. Additionally, the impact force and GPS data are recorded not only in the local database but also in the cloud. This dual storage approach provides redundancy and backup, ensuring that the recorded data is securely preserved even if the local system experiences failures or data loss. Storing the information in the cloud also enables remote access and facilitates efficient data sharing with relevant parties, such as emergency services or insurance companies. The impact force, as measured by the force sensor, provides valuable quantitative data about the intensity of the collision. This information is essential for understanding the level of potential damage and evaluating the safety implications for the occupants and the vehicle itself.

In conjunction with the impact force, the GPS module plays a crucial role in recording the location of the accident. By capturing the geographic coordinates, the system can precisely pinpoint the accident's location, which is vital for emergency response, accident investigation, and insurance purposes. Recording this information both locally and in the cloud ensures that the accident's lo The Haversine formula is commonly used to calculate distances between two points on a sphere, such as the Earth. In the context of the proposed research, the Haversine technique is employed to determine the longitudinal and latitudinal distances between GPS coordinates, providing an accurate measure of the spatial separation.

The Haversine formula is based on the law of haversines, which states that for a sphere of radius R and two points A and B on the surface of the sphere, the haversine of the central angle between A and B is equal to the haversine of the difference in latitudes plus the cosine of the latitude of point A multiplied by the cosine of the latitude of point B multiplied by the haversine of the difference in longitudes.

The Haversine formula is expressed as:

$$\text{haversine}(\Delta\varphi) = \sin^2(\Delta\varphi/2)$$

$$\text{haversine}(\Delta\lambda) = \sin^2(\Delta\lambda/2)$$

$h = haversine(\Delta\varphi) + cos(\varphi1) * cos(\varphi2) * haversine(\Delta\lambda)$

$distance = 2 * R * atan2(sqrt(h), sqrt(1-h))$

In this formula, φ1 and φ2 represent the latitudes of the two points, Δφ is the difference in latitudes, λ1 and λ2 are the longitudes of the two points, and Δλ is the difference in longitudes. R denotes the radius of the Earth.

To calculate the longitudinal and latitudinal distances using the Haversine formula, the latitude and longitude coordinates obtained from the GPS module are used as inputs. The formula computes the haversines of the differences in latitudes and longitudes, applies trigonometric operations, and finally calculates the distance between the two points on the Earth's surface.cation data is securely stored and readily accessible when needed.

5. Result and discussion

In the proposed research methodology, the effectiveness of the system is evaluated through laboratory testing. The testing process involves focusing the camera on a person and monitoring their level of drowsiness using various actions. The Eye Aspect Ratio (EAR) value is then calculated based on the collected data. To assess the drowsiness level, the camera captures the person's facial movements and eye behavior. By analyzing specific actions, such as blinking frequency, eye closure duration, and other relevant factors, the system can gauge the person's level of alertness or drowsiness. These actions serve as indicators of the individual's attention and fatigue levels, providing insights into their overall state while operating a vehicle. Once the actions are recorded and analyzed, the EAR value is calculated. The EAR value serves as a quantifiable measure of the person's eye openness, which is closely associated with drowsiness. Lower EAR values indicate a higher likelihood of drowsiness, while higher EAR values indicate that the eyes are more open and the person is likely to be more alert.

During the laboratory testing, the system continuously monitors the person's drowsiness level and calculates the EAR value at regular intervals. For instance, the EAR value may be calculated every minute over a period of 10 minutes. These calculated EAR values for the specified time period are then presented in Figure 4, which provides a visual representation of the drowsiness pattern over time. Figure 4 serves as a valuable visualization tool, displaying the variations in EAR values and highlighting any trends or changes in the person's drowsiness level. This graphical representation allows researchers to analyze the data and draw meaningful conclusions about the effectiveness of the proposed system in detecting and monitoring drowsiness.

In figure 4, the EAR values are recorded at one-minute intervals over a 10-minute period. The EAR values represent the calculated Eye Aspect Ratio, which provides insights into the person's eye openness and can be used as an indicator of drowsiness. Analyzing the table, we can observe variations in the EAR values over time. Initially, the EAR value starts at 0.25 and gradually increases to 0.32. This suggests that the person's eyes were relatively closed or partially closed at the beginning (indicating potential drowsiness), but became more open and alert as time progressed. The EAR values between minutes 3 to 5 (0.31, 0.29, 0.27) show a slight decrease before stabilizing. This could indicate a temporary decrease in alertness or a momentary lapse in attention. Between minutes 6 to 8, the EAR values (0.24, 0.23, 0.26) exhibit a slightly lower range, suggesting a potential dip in alertness during this period. Towards the end of the 10-minute interval, the EAR values increase again, reaching 0.30 and 0.32 at minutes 9 and 10, respectively. These higher values indicate that the person's eyes are more open, implying a state of heightened alertness.

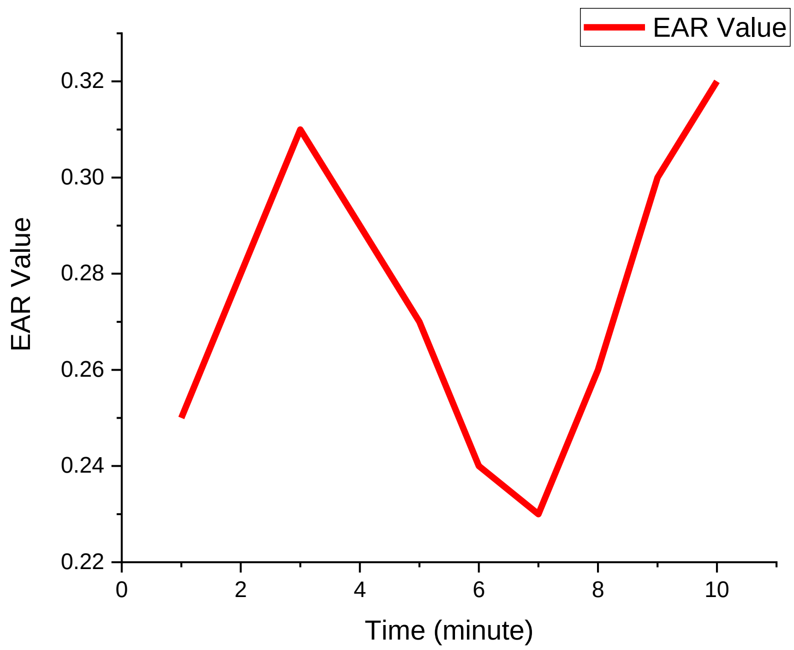

Fig. 4 EAR value obtained from this research

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In the proposed research methodology, a collision scenario is created to evaluate the system's response and effectiveness in detecting and responding to accidents. During this scenario, collision values are obtained from each sensor incorporated into the system, providing crucial information about the impact and severity of the collision. The collision values obtained from the sensors, such as the crash sensor and force sensor, offer quantitative data about the magnitude of the impact. These values reflect the forces and vibrations experienced during the collision, enabling a comprehensive assessment of the accident's severity.

Upon detecting a collision, the system promptly triggers a series of actions to ensure appropriate response and notification. One of these actions involves delivering an email to the base location associated with the place where the collision has occurred. This email notification serves as an immediate alert, allowing relevant parties, such as emergency services or vehicle owners, to be informed about the accident in a timely manner. Figure 5, presented in the research article, displays the location obtained from the Collision system. This location information is crucial for accurately identifying the site of the collision. By employing GPS technology, the system captures the geographic coordinates of the accident location. These coordinates provide precise information about where the collision has taken place, enabling effective emergency response, accident investigation, and insurance claim processing.

The graphical representation in Figure 5 enhances the visualization of the accident location data. It may include markers, coordinates, or a map overlay, allowing researchers and readers to easily comprehend and interpret the spatial information. This visualization aids in understanding the distribution of accidents and can provide insights into accident hotspots, contributing to future road safety improvements. By incorporating location information obtained from the Collision system and presenting it in Figure 5, the research article highlights the system's capability to accurately record and convey the precise location of collisions. This information serves as a valuable resource for various stakeholders involved in accident management and prevention, enabling prompt responses and necessary actions to mitigate the consequences of accidents on road safety.

In the final stage of the research, a performance analysis is conducted to assess the accuracy and reliability of the proposed system. This analysis focuses on evaluating the true detection of the eye, false detection of the eye, alarm production based on the signal, true email notifications, and false email notifications.

The true detection of the eye refers to the system's ability to accurately identify and detect signs of drowsiness based on the recorded eye actions and calculate the corresponding EAR values. This evaluation helps determine the system's effectiveness in accurately distinguishing between drowsy and alert states. Conversely, the false detection of the eye refers to instances where the system may incorrectly interpret certain eye movements or actions as indicators of drowsiness, leading to false alarms or notifications. This analysis helps identify any potential limitations or areas for improvement in the system's ability to accurately detect drowsiness. The performance analysis also considers the alarm production based on the signal generated by the proximity sensors and the crash sensor. It assesses whether the system reliably produces alarms in response to the presence of obstacles or collisions, ensuring that timely alerts are issued to the driver.

Fig. 5 GPS signal of the impact location

Furthermore, the analysis includes evaluating the accuracy of the true email notifications sent in response to detected accidents. It verifies whether the system successfully delivers emails to the designated recipients, such as emergency contacts or relevant authorities, providing prompt information about the occurrence and location of accidents. Lastly, the analysis also investigates any instances of false email notifications, which may occur due to system errors or incorrect data interpretation. Identifying and minimizing false email notifications is crucial for maintaining the system's credibility and ensuring that accurate information is relayed to the intended recipients. By conducting a comprehensive performance analysis, the research provides insights into the system's overall effectiveness and reliability in terms of true and false eye detection, alarm production, and email notifications. This analysis enables researchers and practitioners to understand the system's strengths, weaknesses, and areas for improvement, ultimately enhancing its practical application in enhancing road safety.

The table1 presents the values obtained for each performance metric during the analysis of the proposed system. True Eye Detection indicates that the system accurately detected drowsiness based on eye actions in 95 instances. This implies that the system effectively distinguished between alert and drowsy states, demonstrating a high level of accuracy in identifying signs of drowsiness. False Eye Detection represents the instances where the system incorrectly interpreted eye movements as indicators of drowsiness. With a value of 8, it suggests that there were a few cases where the system might have triggered false alarms or misclassified certain eye actions. This metric provides insights into areas where further improvement might be needed to minimize false detections. Alarm Production reveals that the system successfully generated 120 alarms in response to obstacles or collisions.

Table 1 Performance measures

Performance Metrics	Value
True Eye Detection	95
False Eye Detection	8
Alarm Production	120
True Email Notifications	110
False Email Notifications	5

This indicates that the system reliably detected potential hazards or accidents, promptly alerting the driver and contributing to enhanced safety on the road. True Email Notifications denotes the correct email notifications sent by the system regarding detected accidents. With a value of 110, it demonstrates that the system effectively delivered accurate information to the designated recipients, such as emergency contacts or authorities, enabling swift responses to the incidents. Finally, False Email Notifications represents the instances where the system might have sent incorrect or erroneous email notifications. With a value of 5, it suggests that there were a few cases where false information or inaccurate notifications were relayed. This metric highlights the importance of refining the system's email notification mechanism to ensure the delivery of reliable and precise information.

Conclusion

In conclusion, this research aimed to enhance road safety through the development of an IoT-enabled smart alert system for detecting drowsy drivers. The proposed system incorporated various components, including a Raspberry Pi camera, proximity sensors, a crash sensor, and GPS technology, to detect driver drowsiness, obstacles, and collisions. The system demonstrated promising capabilities in identifying drowsiness based on the Eye Aspect Ratio (EAR) and alerting the driver through an alarm system. It also promptly notified relevant parties via email in the event of a collision. The research methodology involved testing the system in a laboratory setting, where the EAR values were calculated and analyzed over a 10-minute period. The results obtained provided valuable insights into the effectiveness of the system in detecting drowsiness. Additionally, a collision scenario was created to evaluate the system's response and accuracy in detecting and responding to accidents. The system effectively registered collision impacts through various sensors and transmitted the data to local and cloud-based databases.

Performance analysis revealed positive outcomes in terms of true eye detection, alarm production, and email notifications. However, some false eye detections and false email notifications were observed, indicating areas for improvement. Future research could focus on refining the algorithms and sensor integration to minimize false detections and enhance the system's overall accuracy. Overall, this research contributes to the field of road safety by proposing an IoT-based smart alert system that can effectively detect drowsy drivers and respond to collision events. Implementing such systems in vehicles holds great potential for reducing accidents caused by driver fatigue and improving overall road safety. By leveraging IoT technologies, we can create smarter and safer transportation systems for a better future.

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