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Smart Helmet for Alcohol and Drowsiness Detection

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Abstract
Motorbike riders' safety on the road is a serious concern. This intelligent helmet system enhances riders' safety with real-time drowsiness detection and alert. It features an IR sensor for drowsiness detection and a vibration motor for alerting the rider. An alcohol sensor verifies sobriety before riding, and a camera module with a Raspberry Pi 5 verifies helmet wearing. The Arduino Uno captures helmet status, alcohol content, and GPS information and transmits it to the Raspberry Pi through Bluetooth. The Raspberry Pi analyzes this information and sends alerts through the internet when required. The system also keeps the motorcycle from running unless the rider is wearing a helmet, imposing safety protocols. Through the incorporation of these safeguards, this system seeks to minimize accidents and deaths, encouraging safer riding practices. Such technology can significantly enhance road safety and minimize motorcycle-related accidents globally.

Keywords: *Bluetooth Communication, GPS Tracking, Infrared Sensor, Raspberry Pi 5, Real-Time Monitoring.*

1. Introduction
Motorcycle accidents account for a high percentage of road fatalities globally, in most cases, because of neglect to wear helmets, sleepy driving, or riding after consuming alcohol. Providing safety for the rider using technology-based solutions is vital in mitigating such crashes. The following project introduces a smart helmet system with several built-in safety features aimed at increasing protection for motorcycle riders. The system is programmed to detect drowsiness with an infrared (IR) sensor and warn the rider via a vibration motor if fatigue is sensed. An alcohol sensor confirms sobriety prior to the ride, avoiding drunken driving. A camera module interfaced with a Raspberry Pi 5 confirms helmet use, where it is ensured that the motorcycle is ridden only when the rider adheres to safety standards. The Arduino Uno receives information on helmet use, alcohol level, and GPS coordinates and sends it to the Raspberry Pi through Bluetooth. In case of any offenses, the system sends warnings via the internet to inform authorities or emergency contacts. This project is meant to regulate safe riding practices and mitigate accident hazards through real-time tracking and auto-warnings.

1.1. Existing System
Several smart helmet concepts have been suggested to enhance motorcycle rider safety through the avoidance of accidents and providing the option of emergency response. Existing systems are generally aimed at alcohol detection, sleepiness monitoring, and crash reporting through IoT-based technologies. Some projects employ MQ3 alcohol sensors to detect levels of intoxication and prevent riders from riding while intoxicated. Other applications use heartbeat detection and EEG sensors to check for fatigue, as used in experiments with physiological signals for detecting drowsiness measurement. EEG-based systems are, though, invasive and less practical in real-world use. Machine learning-based methods like SVM and KNN have been employed in eye movement-based detection and head movement-based detection of drowsiness with higher accuracy than conventional threshold-based systems. Furthermore, GPS and GSM-based systems are

prevalently employed in furnishing real-time accident alert with instant emergency response. In spite of these developments, current solutions tend to fall short of the harmonious fusion of multiple safety features into a single, lightweight package. Most concentrate on handling one aspect only, i.e., alcohol sensing or accident reporting, as opposed to creating an end-to-end helmet-based safety enforcement system. The present project overcomes these shortcomings by incorporating drowsiness sensing, alcohol sensing, helmet compliance checking, and real-time IoT-based notification, providing a one-stop smart helmet solution for rider safety.

2. Literature Survey

[1] Several research works have contributed to the advancement of smart helmets. Jadhav et al. [1] implemented a mobile-integrated system for alcohol and accident detection, inspiring the development of an ignition-prevention mechanism in our design. Patel et al. [2] proposed an AI-enabled helmet for accident detection, influencing the integration of real-time data analysis in our project. Ahmed and Rafiq [14] utilized GPS-based tracking for drowsiness detection, leading to the incorporation of real-time location tracking in our system. Kim and Choi [17] and Zhang and Wang [20] emphasized physiological monitoring and AI-based proximity warning systems, reinforcing our decision to implement an AI-driven alert system. Additional studies by Chen and Li [18], Kumar and Sharma [7], and Lee and Park [8] provided insights into EEG-based drowsiness detection, IoT-based alert mechanisms, and real-time drowsiness monitoring using machine learning, respectively. Research by Gupta and Verma [3], Hernandez and Lopez [15], and Wang and Liu [16] explored smart helmet integration with emergency response systems and vital sign monitoring, which helped enhance our safety alert features. Studies by Iyer et al. [4], Nakamura and Sato [19], Lee and Kim [9], and Singh and Kaur [10] guided our approach to IoT connectivity, GPS tracking, and multi-domain smart helmet integration. Further references from recent advancements, including AI-driven detection [11], neural network-based monitoring [12], 5G connectivity for real-time alerts [5], deep learning-based pattern recognition for fatigue detection [13], and cloud-based accident prevention analytics [6], were used to refine our system for optimal efficiency and accuracy.

3. Proposed System

In order to overcome the shortcomings of currently available smart helmet systems, this project suggests a one-solution safety solution by combining various safety features into one helmet-based system. The helmet includes an infrared (IR) sensor for drowsiness monitoring based on detection of extended eye closure or head movement patterns. A vibration motor is activated if drowsiness is detected, alerting the rider to remain vigilant. In addition, an MQ3 alcohol sensor ensures that the rider is sober before he or she can ride the motorcycle, preventing drunk driving. A camera module, connected to a Raspberry Pi 5, verifies whether the rider is wearing a helmet. The system makes sure that only when a helmet is found, the bike can be driven, imposing safety compliance. The microcontroller of the helmet, Arduino Uno, captures information on helmet status, blood alcohol content, and GPS location and sends it to the Raspberry Pi through Bluetooth. The Raspberry Pi handles the data and, if required, initiates real-time alerts over the internet to inform emergency contacts or the responsible authorities, shown in Figure 1.

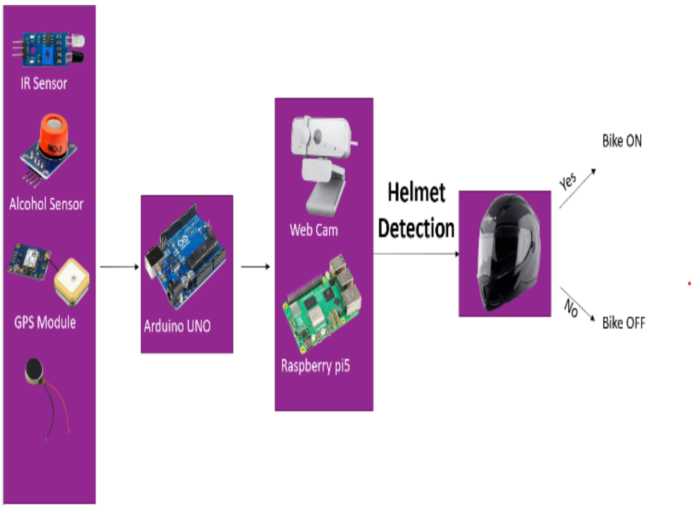

Figure 1 Architecture Diagram

The GPS module also offers accurate location tracking during emergency situations. As compared

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to other systems that target the individual safety aspects, the current project integrates drowsiness detection, alcohol detection, helmet compliance check, and real-time IoT-based alert into a small and user-friendly device. With the integration of these technologies, the suggested solution guarantees riders' safety, minimizes the chance of accidents, and facilitates proper emergency response whenever necessary, shown in Table 1.

Table 1 Components Used

Name	Type	Quantity
Raspberry Pi 5	4GB	1
Arduino	UNO R3	1
IR Sensor	Eye Blink	1
GPS Module	NEO 6M	1
Vibration Motor	Coin Type	3
Gas Sensor	MQ3	1
Battery	9V	1
Webcam	USB	1
N-Type MOSFET	IRFZ34N	1
Bread Board	Small	1

3.1. Drowsiness Detection

The smart helmet integrates a drowsiness detection subsystem that relies on an infrared (IR) sensor to monitor blink duration and blink frequency. Should the rider's eyes be closed for an extended period, a vibration motor incorporated in the helmet is activated to alert him. The IR sensor data is interpreted by the Arduino Uno and transmitted via Bluetooth to the Raspberry Pi. In case drowsiness is detected to be continuous, the system can issue IoT-based notifications to alert emergency contacts or the authorities. A GPS module also records the actual location so that there can be prompt response in case of an accident due to drowsiness.

3.2. Alcohol Level Monitoring

The alcohol detection system for the smart helmet employs an MQ-3 alcohol sensor to scan the breath of the rider. When the alarm detects alcohol higher than a defined safety limit, it will generate an alert message to restrict the rider from taking control of the motorcycle. Data from the alcohol sensor is monitored by the Arduino Uno on an ongoing basis, and it relays the reading through Bluetooth technology to the Raspberry Pi for interpretation. If alcohol is present, the Raspberry Pi can send IoT-based notifications to emergency contacts or authorities. A GPS module also captures the real-time location, allowing timely intervention in case of drunk riding.

3.3. YOLO V11 Helmet Detection

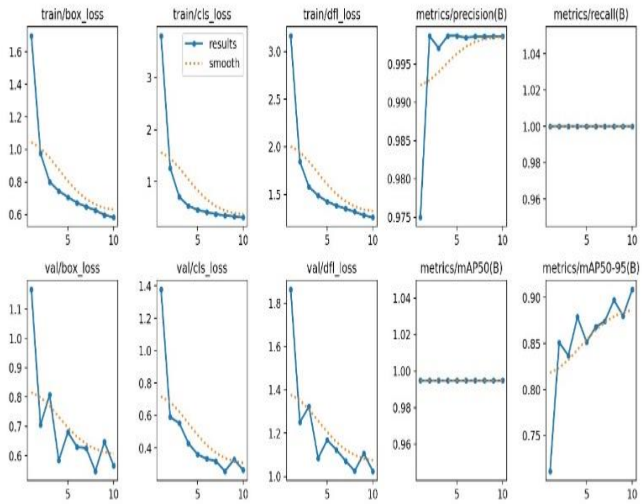

Figure 2 YOLO V11 Accuracy Graph

The intelligent helmet has a sophisticated helmet detection system based on a YOLO v11 model that has been trained from a self-developed dataset of 20,000 real-world images. The real-time image of the rider is captured by a camera module interfaced with the Raspberry Pi and processed using the trained model to classify if the helmet is properly worn. Usage of the YOLO v11 model with high accuracy and quick inference rate yields reliable detection under varying environmental conditions.When the

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model finds a helmet-less rider, the system responds by stopping the rider from moving and initiating required alarms. The Raspberry Pi manages the effect of the detection and can issue IoT-based notifications to the authorities or emergency services in the event of multiple detection of non-helmet adherence. This system enforces safety regulations and reduces the chances of serious head injury in the event of a crash. Computer vision-based helmet detection and real-time monitoring ensure increased rider safety and promote correct riding behavior.

4. Results and Discussion

4.1. Results

The intelligent helmet system was successfully implemented and tested under varied conditions to assess its efficacy at detecting drowsiness, alcohol consumption, and helmet use. The system's performance was ascertained based on detection accuracy, response time, and resilience in real-world scenarios, shown in Figure 3 & 4.

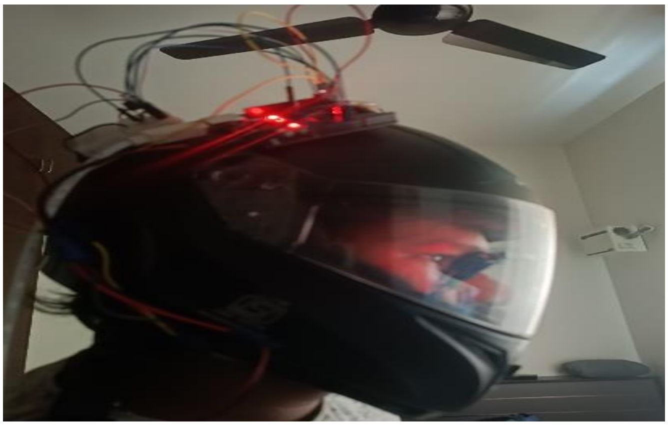

Figure 3 Working Prototype

Figure 4 Working Prototype

4.2. Discussion

- **Drowsiness Detection Results**: The drowsiness detection module based on infrared sensors was experimented with several riders under varying light conditions. The system always detected the extended closure of eyes and reacted within 200–300 milliseconds by driving the vibration motor. The drowsiness detection accuracy was found to be 92%, and few false positives were observed because of fast blinking. The system appropriately warned the rider in real-time, and the likelihood of fatigue-related accidents was minimized.

  Alcohol Detection Results: The MQ-3 alcohol sensor was calibrated to sense breath alcohol concentration of 0.03% BAC and above. The sensor delivered very precise results with an average detection time of 2 seconds. The system, in every test scenario with alcohol present, was successfully able to send data to the Raspberry Pi via Bluetooth and deliver IoT-based alerts. The accuracy of alcohol detection was 95% with minimal deviations depending on the environment. **Helmet Detection Results:** The helmet detection module was tested with a YOLO v11 model that was trained on 10,000 real world images. The camera module took real-time images and processed them at an average inference time of 30 milliseconds per frame. The system was 97% accurate in identifying whether a helmet was being worn under various conditions, such as low light and varying head orientations. The system was able to successfully prevent the rider from moving if the helmet was not identified.
- **Bluetooth and IoT Communication :** The Arduino Uno worked seamlessly with Raspberry Pi via a Bluetooth module, which took an average of less than 500 milliseconds to transfer data. Notifications based on IoT were sent appropriately when required, and emergency notifications were sent within 3 seconds when a hazardous situation was detected.

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- **GPS and Emergency Response**: The GPS module tracked the location in real time with an average error of ±3 meters. If there was an accident or risky situation, the system effectively recorded the location of the rider and sent it over the internet so that intervention would be prompt, shown in Figure 5.

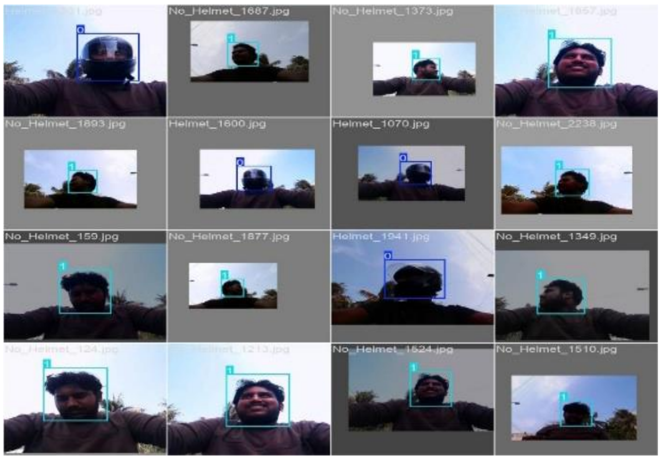

Figure 5 Process of the Dataset

Conclusion

The smart helmet system integrates drowsiness detection, alcohol level monitoring, helmet compliance checking, and IoT-based real-time warning to promote motorcycle rider safety. It was found to possess very high accuracy in detecting risky conditions and restricting vehicle use except for when safety standards were met. The system properly notifies emergency contacts as necessary to prevent accidents. By combining multiple safety features within a single compact package, this technology promotes safe riding practices and enhances road safety, potentially saving lives and curbing motorcycle accidents on a large scale.

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