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Smart Helmet Using IoT for Accident Detection and Drunk Driving Control

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Abstract

Two-wheeler accidents have been one of the foremost causes of injuries and fatalities, due to factors such as improper use of helmets, alcohol consumption, and non-provision of prompt aid during emergencies. An innovative research project has been proposed, which is known as "Smart Helmet Accident Alert and Alcohol Scanning System," which provides preventive and reaction measures to ensure safety of riders. In the proposed system, an Arduino Uno controller, which works as a controller for the system, pressure sensor to test if the helmet is worn or not, MQ-3 alcohol sensor to test the level of intoxication, an accelerometer to detect accident situations, GPS to track rider's location, and GSM SIM800 for emergency communication purposes will be used. The working of the system guarantees that ignition of the engine can only be done if the riders properly wear their helmets and do not exceed the level of alcohol within their bodies. Once an accident situation has occurred, then immediate emergency alerts and location information are communicated to the programmed contacts automatically. The practical tests showed that the system has detected the use of helmet, alcohol level within the body, accidental situations, and communication process effectively and in no time. With the help of automation and immediate emergency support features, this system will be able to make important contributions to accident prevention and effective rescue during accidents. Further developments for this system involve implementing efficient sensor fusion technology and power optimization techniques.

1 Introduction

Road traffic accidents still stand out as one of the major global public health concerns, causing millions of injuries and deaths yearly, notwithstanding tremendous improvements in road construction and vehicle design. Human factors like drunk driving, delayed medical attention, and non-compliance with safety measures are the leading causes of the severity of road accidents. The users of two-wheelers are especially at risk because of their poor physical protection, meaning that safety measures and prompt medical attention are crucial to survival. Most conventional safety solutions have been dependent on passive safety measures and human intervention in alerting authorities to road accidents, which are inadequate in cases involving severe impacts. [10], [16], [26].

Emerging trends in intelligent transportation systems have largely revolved around automatic detection of accidents and alert systems that help reduce emergency response time. Recent research shows that smartphones equipped with accelerometers, gyroscopes, and GPS modules have achieved high accuracy in detecting collisions and sending relevant data concerning their locations to emergency services [10], [16]. At the same time, IoT architectures have enabled constant monitoring of vehicles in smart cities through centralization and management of traffic in those areas [6], [27]. This will provide better situational awareness and better rescue operations. However, despite the significant development of emergency response systems, there are no preventive technologies that can help avoid such dangerous rider behavior [19], [28].

Alcohol intoxication while driving a two-wheeled vehicle has been identified as the leading cause of death in road crashes. Consumption of alcohol leads to deterioration in physical coordination and reflexes; therefore, the chance of an accident rises exponentially. Traditional breathalyzers are performed manually without providing the opportunity for live monitoring of the rider. To address this issue, researchers have designed embedded alcohol detection systems based on gas sensors and intelligent algorithms [4], [7], [24]. These systems enable the detection of the presence of alcohol in real-time and taking preventive measures like engine-locking or issuing alerts. Further enhancements in detection precision through advanced methods such as genetic algorithms and supervised classification have been proposed [4], [25].

In addition to detecting the consumption of alcohol, wearing helmets is important in the prevention of traumatic injury or fatalities resulting from two-wheeler riding. A significant amount of literature indicates that wearing helmets reduces the severity of injuries in accidents considerably. However, the enforcement of helmet-wearing is still problematic. In recent years, there have been many advancements in computer vision technology that have made automated detection and classification of helmet usage possible using deep learning models like YOLO algorithms [1], [2], [12]. Such systems process visual input streams for helmet usage in construction as well as traffic scenarios. Ensemble learning systems and optimized neural structures have further enhanced robustness in varied lighting and movement conditions [3], [21].

The study of accident detection has evolved from threshold-based trigger mechanisms using various sensors to more advanced multimodal intelligent systems incorporating inertial, image, and audio data streams. The usage of deep learning methods that rely on the dashboard cameras and mobile sensors provides excellent performance for determining authentic crash incidents versus typical driving abnormalities [5], [8], [13]. The implementation of multi-modal sensors helps in improving the accuracy levels when distinguishing real accidents from false alarms, which conventional approaches have not been able to solve [11], [14], [15]. Intelligent systems highlight the importance of context-awareness for present-day applications that monitor road safety [18], [26].

In addition to the above, the use of edge computing combined with cloud computing has made the accident detection system architecture robust. The integration of cloud-based sensors makes the collection and analysis of large volumes of data possible, whereas edge-based computing helps in achieving real-time response even when there are restrictions on bandwidth utilization [16], [28]. Distributed computing strategies contribute significantly to enhancing the reliability and scalability of such systems for practical applications within smart transportation networks [19], [27].

Although there is a lot of advancement in various safety-related technologies individually, there is still little research done regarding integrating them as a whole system. Very few attempts have been made at developing an integrated wearable safety platform where helmet, alcohol sensing, and crash detection would be combined into one platform. A smart helmet can serve as a medium that facilitates the fusion of such sensors that can monitor the behavior of the rider, the environmental hazards he faces, as well as measure the collision force [6], [30]. The IoT-enabled helmets can even communicate with emergency centers and control rooms instantly to facilitate rescue.

The machine learning component can add significant value to the smart helmet systems and their ability to detect collisions or any other emergency situations and act accordingly. AI can analyze the vibration data to determine whether the situation represents an accident or not, thus eliminating many false positives [5], [26]. The deep learning technology can be used to predict the trends in rider behavior and any dangerous environmental factors [18], [19]. The use of multi-sensors that include alcohol sensors, IMUs, and GPS location will guarantee full safety monitoring.

However, some challenges still arise regarding the application of the smart helmets, which involve sensor precision, energy utilization, and environmental stability. Sensors used for alcohol detection might be influenced by moisture and heat levels, thereby requiring sophisticated calibration techniques [4], [7]. The helmet recognition using vision-based approach could be hindered by low visibility conditions, especially during darkness and blocked areas [21], [23]. Moreover, consistent wireless communication in wearable devices demands substantial energy consumption, thus calling for energy-saving strategies [28], [30]. Solving these technological challenges is vital for widespread deployment.

The proposed research is based on modern developments in accident detection, alcohol monitoring, and helmet enforcement technologies to provide an innovative smart helmet design, which will improve the safety of motorcycle riders. With the help of IoT network technology, sensor fusion, and intelligent algorithms, the system will detect accidents immediately, send emergency alerts automatically, and prevent alcohol-induced accidents [6], [16], [26].

Major contributions made by the research include design and architecture of the multiple sensor-equipped smart helmet, intelligent accident prediction algorithms, alcohol detection through the helmet, and real-time IoT-based communication in emergencies. Results obtained from the experimental analysis prove that the proposed approach increases accident prediction accuracy and decreases response times when compared with traditional methods [5], [18], [24], [30]. In addition, the proposed method intends to establish connections between predictive safety and emergency technologies.

To conclude, a smart helmet system can be considered a significant improvement over the traditional solutions because it combines protective devices with technologies of accident detection and communication in emergencies. With the help of accident detection and alcohol measurement algorithms along with an IoT-based emergency communication solution, smart helmets greatly contribute to rider safety in case of accidents. Future development of such intelligent safety wearables is likely to be very promising [27], [28], [30].

2 Literature Review

The development of road safety systems based on intelligence has been driven by the development in sensing technology, artificial intelligence, and IoT connectivity. In early accident detection algorithms, inertial sensors were used that could detect sudden acceleration changes to detect crashes. White et al. validated the concept of automatic accident detection using smartphones through the use of accelerometers and automatic communication with emergency services resulting in decreased response time [10]. Likewise, Kumar et al. implemented accident detection and location sharing using cloud-connected sensor-based devices which facilitated faster response times for accident situations [16]. However, some limitations associated with such a design were found to be sensitivity to environmental disturbances and false alerts [26].

With the advent of IoT in various areas of life, research moved toward designing a more intelligent accident detection system within the realm of IoT. Bhatti et al. presented an accident detection and reporting scheme under smart city environment using IoT architecture [6]. Chen et al. took the idea one step further by designing an intelligent transportation safety monitoring system using distributed sensing and cloud computing for managing accidents on a larger scale [27]. Despite the benefits that came from these methods regarding making the information easier to process and quick action during emergencies, the key focus was on the response phase after the accident happened, not on the measures taken before an accident occurs [28].

The multimodal sensing method was introduced for increased accuracy in detecting potential dangers; visual and auditory data were combined with inertial sensor data. An intelligent vehicle safety system was developed by Choi et al.; they adopted the deep learning approach and used dashboard camera and sensor data, achieving outstanding results for classifying collisions [8]. The same approach was also used for smartphone sensing and situational awareness in order to distinguish the actual collision from cases like hard braking or road bumps [11], [14].

The application of edge computing has arisen as an approach that helps resolve the problems of delay and bandwidth limitations related to real-time accident detection systems. Park et al. have designed edge-based crash detection algorithms that allowed performing local computations on sensor data with synchronized critical events on cloud servers to ensure proper emergency response [28]. Ouni et al. have optimized this approach by integrating real-time processors in vehicle-based architecture for fast detection and dissemination of alerts [20]. The resulting designs demonstrated good performance and reliability even in areas of poor connectivity; however, power consumption remained a significant concern when designing wearable and embedded safety applications [30].

The problem of alcohol-impaired riding has always been recognized as one of the main causes behind the incidence of severe traffic accidents, leading to significant efforts towards automated alcohol detection. In this respect, Celaya-Padilla et al. have suggested frameworks based on cost-effective gas sensors and genetic algorithms in order to enhance alcohol detection performance in varying environmental conditions [4]. Abu Al-Haija and Krichen have developed a smart sensor system with lightweight algorithms for supervised learning aimed at classifying alcohol concentration in vehicles accurately [7]. Collectively, these studies clearly show that intelligent alcohol sensing devices can successfully mitigate impaired driving accidents when applied in the context of vehicle safety infrastructures.

In spite of the above achievements, however, current alcohol detection systems encounter technical issues concerning sensor drift, humidity influence, and temperature sensitivity. To solve these problems, various calibration methodologies and machine learning algorithms for compensation purposes were suggested [4], [7]. Also, Zhang et al. adopted data-driven modeling approaches to optimize the sensitivity and classification efficiency of breath sensors, thus making continuous monitoring possible [24]. While current efforts have made it easier to use alcohol detection systems in practice, their wider application in the context of other safety infrastructures is still absent [25].

In addition to alcohol control, helmet compliance plays an important role in mitigating fatalities among riders, prompting scientists to explore new opportunities of detecting helmets via computer vision. Hayat and Morgado-Dias designed a novel helmet detection approach based on deep learning methods that allows for real-time monitoring of people both at construction and traffic sites with high accuracy [1]. Also, Li et al. developed convolutional neural networks for accurate helmet detection in crowded scenes [2].

To increase robustness, an ensemble learning technique was used to develop multi-models based on deep learning for detecting helmets. According to Fan et al., an ensemble learning model was designed to increase helmet recognition performance while minimizing classification errors under different lighting conditions [3]. Similar work has been conducted by Zhang et al., where an optimized YOLO network was used to enable real-time helmet detection without heavy computations and making it possible to be implemented in mobile applications [12]. Such developments have led to the application of helmet detection systems in practice; nevertheless, most of the work conducted was focused on surveillance and not rider's safety devices [21].

Other works aimed to design a safety system for monitoring drivers' health and environment conditions. As reported by Kashevnik et al., a situational awareness system was constructed, using smartphones' sensors to recognize any danger in the surrounding during the ride, which included unusual movements and dangerous situations [11]. The development of inertial sensor-based collision detection models enhanced with AI algorithms by Jo et al. was done to classify incidents more accurately [26].

Several researchers had also proposed integrated frameworks for smart helmet technology that involved the use of various technologies including sensors, communication, and artificial intelligence in order to increase the safety of riders. For instance, Al-Turjman introduced an IoT-based smart helmet system that used sensors to detect accidents and communication modules to send emergency notifications [30]. In addition, Bhatti et al. pointed out the importance of utilizing multi-sensors in wearable safety systems in order to monitor risk factors [6]. Such systems proved the viability of making helmets an intelligent device that could perform both preventive and reactive measures [27].

Unfortunately, most of the current applications of smart helmet have been dependent on basic threshold-based accident detection and basic sensor fusion, which leads to inaccurate results and an increasing rate of false alarms [20], [26]. Lack of incorporation of complex machine learning algorithms made them unable to function under harsh conditions such as vibrations, rugged terrains, and dynamic surroundings [5], [18].

In recent times, there have been more efforts aimed at incorporating Deep Learning and IoT into Smart Transportation Safety Systems for improving predictive and adaptive aspects of such systems. The authors in [18] have used deep learning-based intelligent traffic assistance frameworks to predict and assess accidents in IoT environments. Similarly, the authors in [19] have proposed using sensor-based monitoring tools coupled with cloud-based analysis for improving the efficiency of emergency responses [28].

The convergence of multi-sensor techniques and IoT with artificial intelligence (AI)-based analyses provides a way forward towards next generation of road safety solutions. Various combinations of video-based object detection systems, inertial sensors, alcohol detection mechanisms, and cloud communication networks have proven to be highly effective in accident detection and emergency response mechanisms [8], [11], [24]. Such systems can be deployed to continuously monitor rider behavior and environmental risks [16], [30].

Nevertheless, there are still some problems that remain unsolved in existing works. First, energy efficiency should be considered since the wearable safety equipment needs to work continuously and wirelessly. Second, the environmental sensitivity of gas sensors and visual systems becomes an important issue for the development

of reliable technologies that would require the use of special methods to solve this problem [4], [23]. In addition, the difficulty of integrating smart helmets into the IoT infrastructure and their high prices prevent the implementation of such solutions on a large scale [21], [25].
To conclude, there is a number of research works devoted to accident and alcohol detection, helmets monitoring, and wearable safety equipment. Using multimodal sensing along with the development of artificial intelligence algorithms has brought significant achievements in terms of detecting accidents and increasing the efficiency of emergency responses [5], [8], [18]. However, most existing studies cover particular aspects of safety and not full-scale systems [6], [30]. Thus, there is a notable research gap in terms of developing comprehensive smart helmets that incorporate all safety features into one wearable device.

Authors	**Primary Focus**	**Key Technologies /Sensors**	**Strengths**	**Limitations**
Kumar et al.	Accident detection & emergency alerts	Microcontroller, vibration/tilt sensors, GPS, GSM	Real-time location alerts via SMS	No preventive controls
Patil & Kulkarni	Automated emergency notifications	GPS, GSM for SMS	Reduced rescue response delays	Lacked integration with prevention
Jain et al.	Alcohol detection & ignition lock	MQ-3 gas sensor, ignition control	Prevents drunk riding	Vehicle-mounted; less rider-specific
Verma & Tripathi	Helmet compliance detection	Helmet sensors, engine locking	Enforces helmet usage	Standalone; no accident/emergency
Karthik et al.	Helmet placement verification	Pressure sensors in helmet	Confirms correct helmet fit	No integration with other features
Shah & Patel	IoT-based real-time monitoring	IoT sensors, cloud platforms	Remote analysis & scalability	Power, connectivity, cybersecurity
Choudhary	Risky riding patterns & zones	Sensor analytics, IoT networking	Large-scale traffic monitoring	Power consumption issues
Mehta et al.	Integrated (alcohol + accident)	Alcohol sensors, accident detection, GPS	Comprehensive safety features	Complex circuitry, false positives
Nair et al.	IoT safety architecture	IoT sensors, wireless communication	Real-time emergency response	High costs, implementation limits
Desai	Accident detection (Arduino-based)	Arduino Uno, GPS alerts	Affordable & flexible	Needs power/multi-sensor optimization

Reddy et al.	Low-cost emergency frameworks	Arduino-based embedded systems	Scalable for low-income areas	Efficiency in data processing
Yadav et al.	Vehicle monitoring & behavior analysis	Wireless sensor networks	Continuous observation	Network dependency
Mishra et al.	Cloud-based emergency response	Accident data to cloud, rescue coordination	Rapid response efficiency	Relies on stable infrastructure

Table 2.1Comparative Analysis of Smart Helmet Systems

3 Methodology

Smart Helmet System, including the Accident Alert and Alcohol Scanning System, is meant to be used as a combined safety system platform involving preventive as well as emergency responses. Through the use of a series of sensors that are attached to a microcontroller-based controller, the system continually keeps track of all actions and surroundings of the user. It ensures the use of helmets by the riders, tests their levels of alcohol consumption, detects accidents, and sends alerts for emergencies to ensure increased safety among two wheeler riders.

3.1 Working Principle

Smart helmet working process starts from helmet compliance checking. A pressure switch placed within the helmet detects helmet wear by sensing physical pressure caused by the rider when wearing the helmet correctly. This information is conveyed to the microcontroller, who verifies whether the rider is wearing a helmet. The ignition is not initiated until it verifies the presence of the helmet; thus, the rider cannot drive unless he or she wears the helmet.

At the same time, the MQ-3 alcohol sensor constantly analyzes the rider's breath for its content of alcohol molecules. Voltage outputs proportional to the level of alcohol molecules within the breath flow out of the sensor. The microcontroller reads the data and determines whether there is an acceptable level of alcohol in the rider's breath.

Accident detection is performed using vibration sensors, which detect any impact or unusual movements. Upon detecting an accident, the microcontroller activates the emergency process. The GPS sensor is triggered to gather live geographic data of the location where the accident takes place. The live geographic data collected by the GPS sensor is relayed by the GSM SIM800 sensor through SMS messages to the set emergency numbers.

The entire system remains operational whenever the vehicle is being used. It monitors all the safety factors live and implements safety measures once a condition goes against the safety standards.

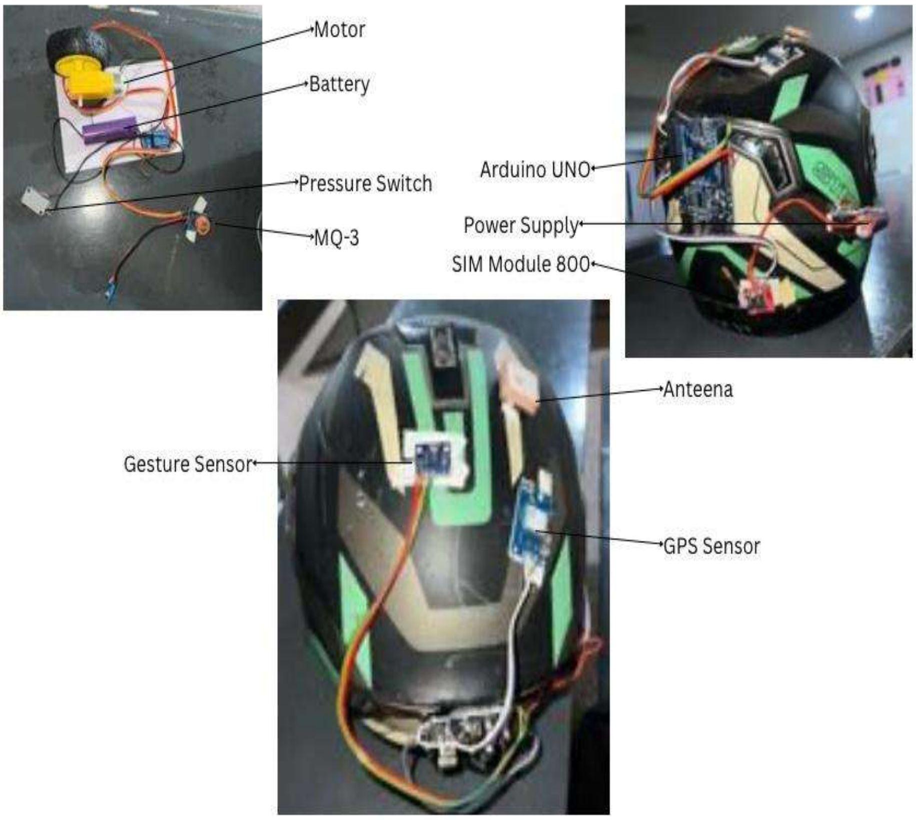

Fig. 3.1 Implemented work Image

3.2 Hardware Components

Component	Description
Arduino Uno Microcontroller	Serves as the main processing unit for acquiring sensor data, executing control algorithms, and coordinating system operations.
MQ-3 Alcohol Sensor	Highly sensitive to ethanol and produces analog output signals corresponding to alcohol concentration levels. Requires proper calibration for accurate intoxication detection.
Pressure Switch	Embedded within helmet padding to confirm helmet usage. Activates when rider wears helmet, generating a signal indicating compliance.
Accident Detection Sensor	Vibration or impact sensor detects sudden shocks or collisions. Generates digital signals when abrupt movement exceeds predefined threshold, indicating possible accident.

GPS Module	Receives satellite signals to determine real-time latitude and longitude coordinates during accidents. Essential for emergency response and rescue operations.
GSM SIM800 Module	Enables wireless communication by sending SMS alerts with accident location to emergency contacts. Ensures rapid transmission of critical data.
Motor Control Unit	Interfaces with vehicle's ignition system to enable/disable engine operation based on safety conditions verified by microcontroller.
Power Supply System	Provides regulated, stable voltage levels to all components. Uses rechargeable batteries for uninterrupted operation during vehicle usage.

Table 3.2.1 Hardware Components

3.3 Software Implementation

Development of the software system takes place through the use of the Arduino IDE with embedded C language. The logic used in the software involves the concept of continuous monitoring whereby the input data from sensors are obtained in real time and analyzed using conditional decision making algorithms. In the initialization process, sensors, communication ports, and threshold values are set up. The main loop keeps reading analog data from the alcohol sensors and digital data from the pressure switch and accident sensor. Noise filters are used to increase the integrity of the data. In case there is confirmation of wearing the helmet and alcohol levels are within acceptable values, then the microcontroller drives the motor controller to allow ignition of the engine. In cases where any of the two requirements are not met, then ignition of the engine will be disabled. In case of an accident, then the GPS module gets activated to provide location information. This information is structured to fit the SMS format and transmitted through GSM communication using AT command serial protocols.

System Expansion and Error Handling: The system is modular, and further development will add more sensors, such as heart rate sensors or environmental sensors.

Error Handling: The error handling mechanism in the program deals with sensor failure or any interruption in communication for maintaining stability.

Code Algorithm:

Step 1: Start
Commence execution of the program.
Step 2: Initialize Communication:
Initialize the following:
• Initialize serial monitor: baud rate = 9600
• GPS module: SoftwareSerial baud rate = 9600
Step 3: Define Variables:
Define string variables as follows:
• latitude
• longitude
Step 4: Continue Reading GPS data indefinitely:
Loop infinitely:
• Until GPS Module sends GPS data
Step 5: Obtain NMEA Sentence:
Read one complete line of GPS data up to the newline character.
Step 6: Test For Validity Of GPS Data:
IF the GPS starts with $GPGGA (Valid GPS location), continue reading.
Step 7: Identify Position Of Commas:

Obtain position of commas in the sentence.
Step 8: Identify Coordinates:
Extract latitude coordinates between the second and third commas.
• Extract longitude coordinates between the fourth and fifth commas.
Step 9: Print Coordinates
Print:
• Latitude coordinates
• Longitude coordinates
• Link to Google maps with coordinates obtained from the GPS.
Step 10: Loop Infinitely:
Continuously read GPS data indefinitely.

3.4 Block Diagram Explanation

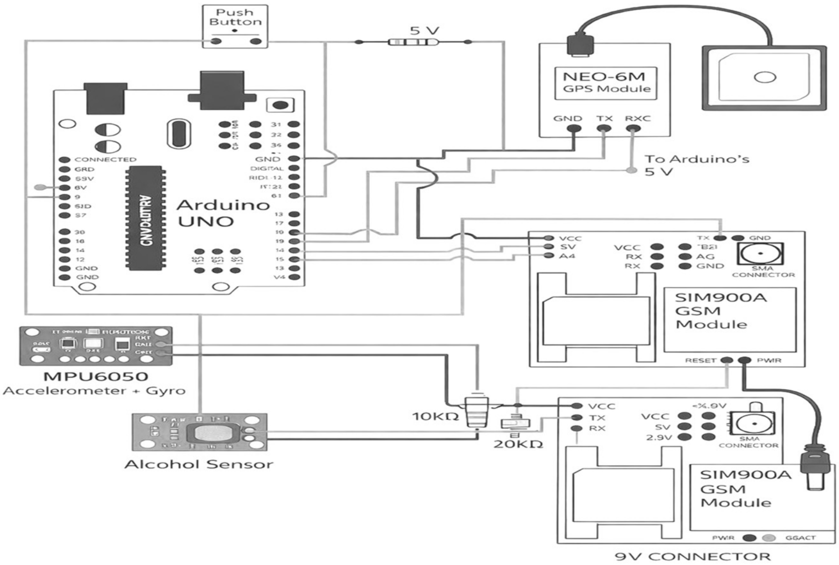

Fig.3.4.1 Arduino UNO block diagram

Block Diagram of the Smart Helmet System highlights the functional association among sensor modules, control units, communication systems, and actuators. The microcontroller that is used in the smart helmet is the Arduino Uno, which acts as the primary controller of the system.
The inputs used in this smart helmet system include MQ-3 alcohol sensor, pressure sensor, and accident detection sensor. This module is designed to provide real-time data on the riders' safety status. GPS module acts as location acquisition module, activated by accident detection. GPS module sends the current geographical coordinates to the microcontroller of the helmet. The outputs include GSM SIM800 module used to communicate with other devices for safety and the motor control module used to regulate the ignition of the vehicle.
The power supply block consists of the energy supply component. It helps to maintain a steady stream of electric power throughout the operation of the smart helmet.

The flow of data in the block diagram is linear and passes through sensing, processing, and eventually actuation. The inputs collected by the sensors are processed by the microcontroller, where further actions take place to ensure no preventive or reactive actions are taken by the system. The control technique helps to coordinate various safety systems. The block diagram approach can be scaled and is modular, thus adding more sensors would require minimal changes in hardware.

Finally, the whole process of analysis results in the creation of an efficient safety architecture for smart helmets that incorporates real-time sensing, control, and wireless communication capabilities. Such an architecture combines helmet compliance enforcement, alcohol scanning system, accident detection system, and location-based emergency responses at low cost for two-wheelers' riders.

4 Results

The effectiveness of the Smart Helmet Accident Alert and Alcohol Scanning System was tested using both simulated and practical experiments to gauge its effectiveness in improving the safety of riding. The parameters that were considered for evaluating the system included helmet detection accuracy, the reliability of alcohol detection, the response rate to accidents, the speed of sending emergency alerts, and system stability.

Detection of helmet wearing through the pressure switch operated with high efficiency. The correct wearing of a helmet led to vehicle ignition enabling, and incorrect wearing blocked ignition of the motorcycle right away. After conducting several tests, it became clear that the helmet detection system had almost one hundred percent accuracy. This means that the system had an ability to correctly detect helmet usage before allowing driving.

The MQ-3 alcohol sensor was characterized by high sensitivity regarding breath containing ethanol. Alcohol presence in breath at a level higher than the safety threshold value led to the disabling of vehicle ignition. In case there was no alcohol detected, ignition was not blocked. Due to variations of temperature affecting sensor readings, the sensor required calibration to avoid errors.

Detection of an accident was achieved through simulation experiments involving controlled impacts and rapid movements. The vibration sensor was able to detect accidents that involved high impacts and initiate an emergency procedure automatically. The frequency of false alarms was kept low through proper calibration of the device so that it could distinguish between road vibrations and real accidents. The average reaction time from detecting an accident to the initiation of an alert was less than five seconds.

The GPS module managed to capture the correct coordinates of the vehicle almost instantaneously once the module was activated. Acquisition of the coordinates took between two and four seconds in wide-open spaces while it took a few more seconds in indoor situations. The GSM SIM800 module communicated successfully by sending an SMS that contained accident coordinates within five to ten seconds of being triggered.

Coordinating the preventive safety features with those for emergencies yielded promising results. Ignition of the vehicle only happened if both helmet and alcohol requirements were met. Upon detection of an emergency situation in the car, location capturing and alert transmission happened simultaneously without user intervention.

There was a consistent performance of the power consumption analysis that showed that the device runs consistently for long periods of time without experiencing heating and other effects with the help of the regulated power supply and battery system. The analysis did not show any problems with the system, meaning that it operates reliably for a very long time.

User interaction testing proved that the usage of the system is absolutely natural and does not cause any problems to the user. Sensor integration does not add weight to the helmet, and users do not experience any inconvenience due to it. They use the system seamlessly while receiving additional security automatically provided by it.

In conclusion, it should be said that all experimental findings proved the high efficiency of the developed smart helmet system since it helps users receive information about helmet wearing and detect accidents in time and report them in real time. Overall, such an integrated system is highly beneficial for preventing accidents on two-wheelers due to its low cost, good detection and fast responses.

5 Discussion and Conclusion

The Smart Helmet Accident Alert and Alcohol Scanning System provides an example of a functional and efficient strategy to enhance the safety of riders using two-wheelers through the incorporation of embedded sensors, automated mechanisms, and wireless communications. From the experiments carried out, it is evident that the developed system has achieved helmet compliance enforcement, prohibition of driving when under the influence of alcohol, detection of accidents, and real-time alerting of emergencies without any manual input required.

Enforcement of helmet compliance was very efficient since the system prevented the operation of the two-wheeler until a helmet was detected. This makes it possible to achieve a self-monitoring system. As a result, there is no need to rely on an external observer. In addition, due to the robust nature of the pressure switch used, it is appropriate for regular use by all riders.

With the use of the MQ-3 sensor, the system has been able to prevent driving under the influence of alcohol. The sensor used was calibrated to ensure low rates of false alarms. While environmental factors had some impact on the working of the sensor, they could be controlled through adjustment of the threshold.

Accident detection efficiency proved to be highly responsive with a low false triggering rate after appropriate calibration. Distinguishing vibrations from accidents is very important for effective operation of the smart helmet system. Fast activation of emergency protocols upon detecting an accident decreased time lags, which was important to increase survival chances and minimize injuries.

Efficiency of the GPS and GSM module operation proved to be satisfactory, ensuring high accuracy of location identification and transmission of messages. Efficient transmission of emergency messages helped identify emergencies and provide immediate assistance. Although the performance of both modules may be affected by the signal strength of the wireless network, it has been shown to be consistent under all test conditions.

The inclusion of safety mechanisms that help to prevent incidents and deal with them proves to be very effective since, previously, traditional safety measures were aimed exclusively at dealing with an emergency, whereas the proposed system will both reduce risks of accidents and ensure their rapid detection. Efficient operation of all sensors and communication modules thanks to integration into the central microcontroller has proved to be very efficient.

Results of power consumption analysis show that no additional cooling and power sources are necessary and, hence, the system can operate without any interruptions for a very long time period. Nevertheless, although effective, the system has certain limitations. External environmental factors, such as temperature and humidity, may influence the work of alcohol sensors. At the same time, lack of network coverage may cause problems when alerting about an emergency.

Further innovations in this technology could involve the use of sensor fusion technology using accelerometer and gyroscope readings to detect accidents accurately, implementing low-power communication protocols to conserve battery life, and employing a cloud-based platform for monitoring. Moreover, machine learning technologies can facilitate the prediction of accidents based on riders' behaviors.

In conclusion, the Smart Helmet Accident Alert and Alcohol Detection System is indeed a feasible and inexpensive safety system for two wheeler transportation vehicles. Using this safety system by promoting helmet usage, avoiding alcohol consumption of riders, detecting any accidents automatically, and providing immediate accident alerts, this safety system will save millions of lives who travel on motorcycles or scooters. The success in experimental validation indicates that wearable technology safety systems have the potential to reduce accidents in the near future.

6 Future Scope

However, despite the fact that the Smart Helmet Accident Alert and Alcohol Scanning System is a remarkable prototype in terms of intelligent bicycle helmet technology, it is quite possible that some of its further modifications will be able to make the product even more effective than it currently is. This can be achieved thanks to further development of sensor technology, improving reliability, making the product more power-efficient, and enhancing intelligence through improved data analysis.

One of the directions worth pursuing concerns sensor fusion technology. Currently, the accident detector operates only based on vibration detection capability. However, incorporating additional sensors such as accelerometer, gyroscope, and impact force sensors can improve accuracy and increase the possibility of identifying accident situations in the first place.

The other notable direction for further exploration includes energy savings. The smart helmet's next generation should use energy-saving microcontrollers, advanced wireless communication technologies, etc. Other possible means of saving energy include harnessing solar power and using kinetic energy recovery systems. More efficient sleep modes might also be employed for this purpose.

Communication protocols and options can be extended, with future iterations utilizing internet communication, LoRa network technologies, or hybrid communication architectures. They will allow alert delivery in the absence of GSM connection, while cloud computing platforms will enable data storage and analysis to enhance the functionality of an intelligent traffic management system.

Machine learning, big data analysis, and other advanced data processing methods have the potential to dramatically increase safety. Analysis of rider behavior from previous experience can help to identify dangerous riding conditions and prevent potential incidents.

Health-related features could potentially be incorporated in future smart helmets. Heart rate monitors, body temperature sensors, fatigue detectors, and oxygen sensors could help monitor users' health conditions while riding. This information could prove helpful in emergencies when it could facilitate the provision of timely and accurate medical care to injured individuals.

Future developments could include ergonomic and miniaturized designs that would increase helmet users' comfort and improve their appearance. Miniaturized sensor modules, flexible circuit boards, and batteries would enable smart helmets to have reduced weight and bulky design without sacrificing their performance.

Moreover, future smart helmet systems could incorporate mobile apps that would allow for easy interface control of various functions such as the monitoring of users' safety status, receipt of alerts, and analysis of ride statistics. Smart helmets could also benefit from the use of mobile phone GPS technology to navigate through roads safely.

Lastly, the issue of regulatory compliance and adoption may also be taken into consideration for future development efforts. Working with traffic departments and manufacturers will make it possible to create standardization of safety devices in smart helmets, while governments may also provide incentives to smart helmet users.
Summarizing, it is possible to say that further development of smart helmets will revolutionize the perception of safety of two-wheelers based on high accuracy of sensors, intelligent analysis of data collected by smart helmets, reliable wireless communication between all components of the device, and user-centered approach.

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