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SMART HELMET WITH ACCIDENT DETECTION & GPS CONTROL USING NODEMCU ESP8266

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Abstract: This project presents a smart helmet system designed to enhance the safety of two-wheeler riders by integrating accident detection and real-time location tracking using embedded and IoT technologies. The system utilizes sensors such as a gyroscope and proximity sensor to continuously monitor rider movement and helmet usage, ensuring that the vehicle operates only when safety conditions are met. In the event of an accident, the system automatically detects abnormal motion, retrieves the exact geographical location using a GPS module, and sends an emergency alert message to predefined contacts through GSM communication. The NodeMCU ESP8266 or ATmega328P microcontroller acts as the central processing unit, enabling real-time data analysis and wireless communication. Additional features such as RF-based vehicle control and automated alert mechanisms reduce human intervention and improve emergency response time. Overall, the proposed smart helmet provides a cost-effective, reliable, and intelligent solution to minimize accident fatalities and promote safer transportation systems.

I.INTRODUCTION

Road safety has become a major global concern due to the rapid increase in vehicular traffic and the growing number of road accidents, especially involving two-wheeler riders. Motorcyclists are more vulnerable compared to other vehicle users because they lack physical protection, making them highly susceptible to severe injuries and fatalities during accidents. According to various studies, a significant percentage of road accident deaths occur due to delayed medical assistance and lack of timely communication about the accident location [1]. This highlights the urgent need for intelligent safety systems that can automatically detect accidents and notify emergency services without human intervention.

In recent years, advancements in embedded systems and the Internet of Things (IoT) have enabled the development of smart safety solutions aimed at reducing accident-related fatalities. One such innovation is the smart helmet system, which integrates sensors, microcontrollers, and wireless

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communication technologies into a conventional helmet to enhance rider safety [2]. These systems are capable of monitoring rider conditions in real time and responding instantly during critical situations. The integration of IoT allows seamless data transmission, enabling faster communication between devices and emergency responders [6].

Traditional helmets provide only passive protection by reducing the impact of head injuries, but they do not assist in accident prevention or post-accident response. To overcome these limitations, modern smart helmets incorporate features such as accident detection, helmet usage verification, and real-time location tracking [5]. These features not only improve rider safety but also promote responsible driving behavior by ensuring compliance with traffic regulations.

Accident detection is one of the key functionalities of smart helmet systems. It is typically achieved using motion sensors such as accelerometers and gyroscopes that continuously monitor parameters like acceleration, tilt angle, and vibration [2]. When sudden changes in these parameters exceed predefined threshold values, the system interprets it as a potential accident. Early research demonstrated the effectiveness of vibration and pressure sensors in identifying collision events and triggering emergency alerts [1]. However, modern approaches utilize more advanced sensors and algorithms to improve detection accuracy and reduce false alarms [13].

Once an accident is detected, timely communication becomes crucial for saving lives. Smart helmets are equipped with GPS modules that provide real-time geographical coordinates of the accident location [1]. This information is transmitted to predefined emergency contacts through GSM or internet-based communication systems [10]. By automating the alert process, these systems eliminate the need for manual reporting, which is often impossible during severe accidents. Studies have shown that immediate notification significantly reduces rescue time and improves survival rates [9].

Another important aspect of smart helmet systems is preventive safety. Many accidents occur due to negligence, such as not wearing a helmet or driving under unsafe conditions. To address this issue, smart helmets incorporate sensors like infrared (IR) or pressure sensors to detect whether the helmet is being worn properly [12]. Some systems are also integrated with vehicle ignition control mechanisms, ensuring that the motorcycle starts only when the rider wears the helmet correctly [3]. This feature promotes adherence to safety regulations and reduces the likelihood of accidents caused by unsafe practices.

Recent research has also explored the use of advanced technologies such as artificial intelligence (AI) and machine learning to enhance accident detection capabilities. AI-based smart helmets analyze sensor data using trained models to distinguish between normal riding conditions and actual accidents with high accuracy [4]. These systems significantly reduce false detections compared to traditional threshold-based methods. Additionally, edge computing techniques have been introduced to enable faster data processing directly within the device, minimizing response delays during emergencies [9].

The integration of wireless communication technologies further enhances the functionality of smart helmets. RF modules, Bluetooth connectivity, and IoT platforms enable communication between the helmet and the vehicle or smartphone applications [11]. These features allow real-time monitoring, navigation assistance, and improved user interaction. Some systems also incorporate cloud-based storage to maintain historical data, which can be used for accident analysis and traffic management [10].

Moreover, recent developments have extended smart helmet capabilities beyond accident detection to include health and environmental monitoring. Sensors can measure physiological parameters such as heart rate and oxygen levels, providing valuable information to emergency responders during accidents [9]. Environmental sensors can detect air quality and temperature, enhancing rider awareness of surrounding conditions [20]. These advancements demonstrate the potential of smart helmets as comprehensive safety devices in modern transportation systems.

Despite significant progress, challenges such as cost, power consumption, and system reliability remain critical considerations for real-world implementation. Researchers are focusing on developing low-cost and energy-efficient designs to ensure widespread adoption, particularly in developing countries where two-wheelers are

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widely used [6]. The use of compact microcontrollers like NodeMCU ESP8266 and ATmega328P has made it possible to integrate multiple functionalities into a single device without increasing complexity [2].

In this context, the proposed smart helmet system aims to provide an effective and affordable solution for improving rider safety. By combining accident detection, GPS-based location tracking, and automatic alert communication, the system ensures rapid emergency response and reduces dependency on external assistance. The inclusion of helmet usage verification and vehicle control features further enhances safety by encouraging responsible riding behavior. Overall, the integration of IoT and embedded technologies in wearable safety devices represents a significant step toward intelligent transportation systems and safer roads.

II.LITERATURE SURVEY

Recent advancements in smart helmet technology have focused on integrating Internet of Things (IoT), artificial intelligence, and multi-sensor systems to improve rider safety, accident detection accuracy, and emergency response efficiency. The following literature review highlights key contributions from recent studies. A smart helmet system with camera-based monitoring was introduced to enhance rider awareness and accident documentation. The system integrates a miniature camera with motion sensors to automatically record video during sudden impacts, providing valuable evidence for accident analysis and improving situational awareness [16]. This approach extends traditional sensor-based systems by incorporating visual data for enhanced safety monitoring.

Wireless communication technologies have also been explored to improve cooperative safety among road users. A study on smart helmets integrated with wireless sensor networks demonstrated the ability to communicate with nearby vehicles and infrastructure. When an accident occurs, warning messages are broadcast to surrounding vehicles, reducing the risk of secondary collisions and improving overall road safety [17]. This research highlights the importance of connected transportation systems in modern safety applications.

Behavior monitoring has emerged as a proactive safety approach in recent smart helmet designs. Multi-sensor systems incorporating accelerometers, gyroscopes, and pressure sensors continuously analyze riding patterns to detect unsafe behaviors such as aggressive acceleration or sudden braking. These systems provide real-time warnings to riders and significantly improve safety outcomes through preventive measures [18]. Edge computing has been introduced to enhance real-time processing capabilities in smart helmets. Instead of relying solely on cloud-based systems, edge-enabled helmets process sensor data locally, enabling faster accident detection and reducing latency. This approach ensures reliable performance even in areas with poor network connectivity, making it highly suitable for real-world applications [19].

Further advancements include the integration of environmental and health monitoring features. Intelligent smart helmets now incorporate sensors to measure parameters such as air quality, temperature, heart rate, and blood oxygen levels. These systems provide comprehensive safety by monitoring both rider health and environmental conditions, allowing emergency responders to make informed decisions during rescue operations [20].

Recent IoT-based implementations have focused on combining multiple safety features into a single system. These systems integrate helmet detection, alcohol sensing, accident detection, and GPS-based alert mechanisms to ensure complete rider protection. The use of microcontrollers and wireless communication enables real-time monitoring and automated emergency notification, significantly reducing response time [21]. Another study proposed an IoT-enabled smart helmet capable of preventing accidents caused by unsafe riding conditions such as alcohol consumption. The system uses sensors to detect intoxication and disables vehicle ignition if unsafe conditions are identified. It also includes impact sensors and GPS modules for accident detection and alert transmission [22].

Recent research has also explored AI-powered smart helmets that improve detection accuracy using intelligent data processing. These systems analyze sensor data using machine learning algorithms to distinguish between normal riding conditions and actual accidents. AI integration significantly reduces false alarms and enhances system reliability [23].

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A modern IoT-based smart helmet design introduced cloud integration and mobile application support for real-time monitoring. The system collects sensor data and transmits it to cloud platforms, allowing users and authorities to monitor rider status remotely. Experimental results demonstrated high accuracy in accident detection and efficient communication performance [24]. Finally, recent developments have focused on sensor fusion techniques to improve accident detection accuracy. By combining multiple parameters such as tilt angle, acceleration, and impact force within a defined time window, these systems minimize false alarms and enhance detection reliability. Such approaches represent a significant advancement over traditional single-sensor methods [25].

III.PROPOSED SYSTEM

The proposed system aims to develop an intelligent smart helmet that enhances rider safety by automatically detecting accidents and sending emergency alerts along with location information. The system is designed using the NodeMCU ESP8266 microcontroller, which acts as the central processing unit responsible for sensor monitoring, data processing, and wireless communication. The smart helmet integrates multiple sensors and communication modules to monitor rider safety conditions continuously. Sensors such as a gyroscope or accelerometer are used to detect sudden impacts, abnormal tilt angles, or rapid motion changes that may indicate an accident. An IR or pressure sensor is installed inside the helmet to verify whether the rider is wearing the helmet properly. The system allows vehicle ignition only after confirming helmet usage, thereby promoting safe riding behaviour.

ACCIDENT DETECTION MECHANISM

The motion sensor continuously measures orientation and acceleration values during riding. When the sensed values exceed predefined threshold limits, the system interprets the event as a possible accident. The NodeMCU processes these sensor readings in real time and confirms crash conditions by analyzing sudden variations in movement or angle. This automatic detection removes the need for manual intervention.

GPS-BASED LOCATION TRACKING

Once an accident is detected, the GPS module retrieves the current geographical coordinates of the rider, including latitude and longitude values. These coordinates provide accurate location information that can be used to identify the accident site quickly. The location data is processed by the NodeMCU and prepared for transmission.

EMERGENCY ALERT COMMUNICATION

After obtaining the location details, the system automatically sends an emergency notification message to predefined contacts using GSM or Wi-Fi communication. The alert message contains accident information along with a location link, enabling family members or emergency services to reach the rider without delay.

HELMET VERIFICATION AND VEHICLE CONTROL

To ensure rider safety before travel, an IR or pressure sensor checks helmet usage. If the helmet is not worn correctly, the system disables vehicle ignition through a relay control mechanism. This feature encourages riders to follow safety regulations and reduces the risk of accidents caused by negligence.

IOT-BASED OPERATION

The NodeMCU ESP8266 utilizes built-in Wi-Fi capability to enable IoT communication. Sensor data can be transmitted wirelessly for monitoring and alert generation. The use of IoT technology allows real-time communication, remote monitoring, and efficient system control.

BLOCK DIAGRAM

The Smart Helmet with Accident Detection and GPS Control using NodeMCU ESP8266 is an advanced safety system designed to enhance the protection of two-wheeler riders by integrating embedded electronics and Internet of Things (IoT) technology into a conventional helmet. The block diagram illustrates how different sensors, communication modules, and control units are interconnected to create an intelligent and automated safety mechanism. The main objective of this system is to monitor rider conditions continuously, detect accidents automatically, and provide immediate emergency communication along with accurate location details.

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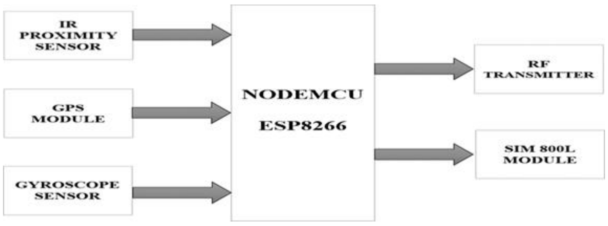

Fig1 : Block diagram of Proposed method

3.1 HARDWARE DESCRIPTION

3.1.1. NodeMCU ESP8266

The NodeMCU ESP8266 is the core unit of the system. It receives input signals from different sensors, processes the data, and controls output devices. The microcontroller continuously monitors helmet status, rider movement, and location information. Based on programmed conditions, it activates communication modules to send alerts during emergencies. Its built-in Wi-Fi capability enables IoT-based communication and efficient data handling.

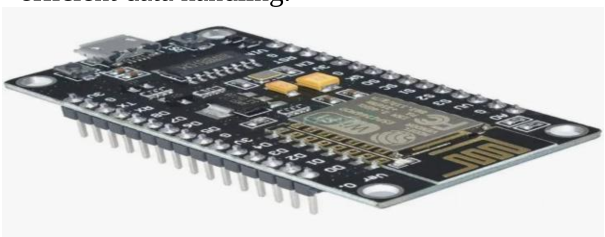

Fig Node MCU ESP8266

IR PROXIMITY SENSOR

The IR proximity sensor is used to detect whether the rider is wearing the helmet properly. It senses the presence of the rider's head inside the helmet using infrared rays. When the helmet is worn, the sensor sends a signal to the NodeMCU confirming safe usage. If the helmet is not worn, the system can prevent vehicle ignition, thereby encouraging safety compliance.

Fig IR Proximity Sensor

GYROSCOPE SENSOR (MPU6050)

The gyroscope sensor measures tilt angle, rotation, and sudden movements of the helmet. It continuously tracks orientation changes during riding. When abnormal motion, sudden impact, or extreme tilt beyond a predefined limit occurs, the NodeMCU interprets it as a possible accident. This enables automatic accident detection without human intervention.

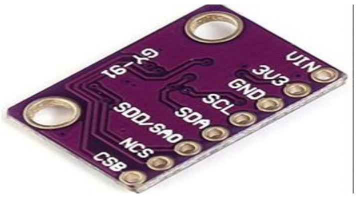

Fig Gyroscope Sensor

SIM800L GSM MODULE

The SIM800L module provides GSM communication capability. Once the NodeMCU confirms an accident, it sends commands to this module to transmit SMS alerts or calls to predefined emergency numbers. The message contains accident information along with GPS location details, allowing quick rescue action.

Fig SIM800L Module

GPS MODULE

The GPS module is responsible for determining the real-time geographical location of the rider. After an accident is detected, it provides latitude and longitude coordinates to the NodeMCU. These coordinates help identify the exact accident location and are included in emergency alert messages sent to contacts.

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Fig GPS Module

The module receives signals from GPS satellites and calculates latitude and longitude coordinates. This location data is transmitted to the controller and included in emergency alerts.

3.1.2. ATMEGA328P MICROCONTROLLER

The ATmega328P is an 8-bit microcontroller developed by Microchip Technology and widely used in embedded systems. It is based on a RISC architecture that provides fast processing with low power consumption. The controller includes 32 KB Flash memory, 2 KB SRAM, and 1 KB EEPROM for program and data storage. It supports communication interfaces such as UART, SPI, and I2C for easy device interfacing. The ATmega328P is commonly used in the Arduino Uno for automation, robotics, and IoT applications**.**

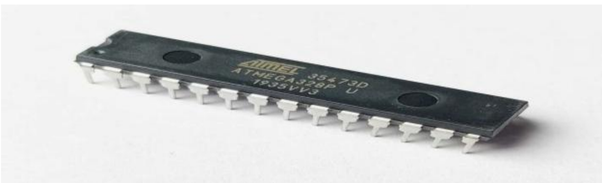

Fig ATmega 328p

RF TRANSMITTER AND RECEIVER(433-MHZ)

The RF transmitter enables wireless communication between the helmet unit and the vehicle or a receiver module. It can be used to control vehicle ignition or transmit safety signals. This wireless link reduces wiring complexity and improves system flexibility.

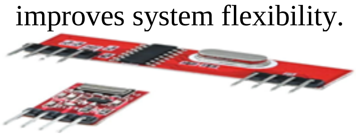

Fig RF Transmitter & Receiver

CHARGING MODULE

A charging module is an electronic circuit used to charge rechargeable batteries safely by regulating voltage and current. It protects the battery from overcharging, deep discharge, and short circuits. The module automatically controls the charging process and stops when the battery becomes fully charged. It is commonly used with lithium-ion and lithium-polymer batteries in portable devices. Charging modules are widely applied in IoT systems, power banks, and embedded electronic projects.

Fig Charging Module

RELAY MODULE

A 12V relay module is an electrically operated switch used to control high-voltage or high-current devices using a low-power control signal from a microcontroller. Its main function is to provide electrical isolation between the control circuit and the load circuit for safety. When a 12V signal energizes the relay coil, it creates a magnetic field that switches the internal contacts from one position to another. This allows devices such as motors, bulbs, fans, or appliances to be turned ON or OFF automatically. The relay module enables automation and remote control in embedded systems and IoT applications while protecting sensitive electronic components.

Fig Relay Module

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IV.IMPLEMENTATION

4.1 Working Principle

The working principle of the smart helmet system is based on continuous monitoring of rider safety conditions using sensors, real-time data processing through a microcontroller, and automatic communication during emergency situations. The NodeMCU ESP8266 acts as the central unit that coordinates sensing, decision-making, and alert transmission.

Initially, when power is supplied, the system becomes active and all connected modules start functioning. The IR proximity sensor placed inside the helmet checks whether the rider is wearing the helmet correctly. If the sensor detects the presence of the rider's head, a signal is sent to the NodeMCU confirming safe usage. Only after this verification can the vehicle ignition system be enabled through wireless communication, ensuring that the rider follows safety rules before starting the ride.

The smart helmet works by continuously monitoring rider safety using sensors connected to the NodeMCU ESP8266 microcontroller. When the system is powered on, the IR sensor checks whether the helmet is properly worn and allows vehicle operation only after confirmation. During riding, the gyroscope sensor measures motion and tilt angles to observe normal movement conditions. The NodeMCU processes sensor data in real time and detects abnormal changes that may indicate an accident.

If an accident is identified, the GPS module obtains the rider's current location coordinates. The NodeMCU then activates the GSM module to automatically send an emergency alert message along with location details to predefined contacts. This automatic communication ensures quick assistance even if the rider cannot request help manually, thereby improving safety and reducing emergency response time.

FLOW CHART

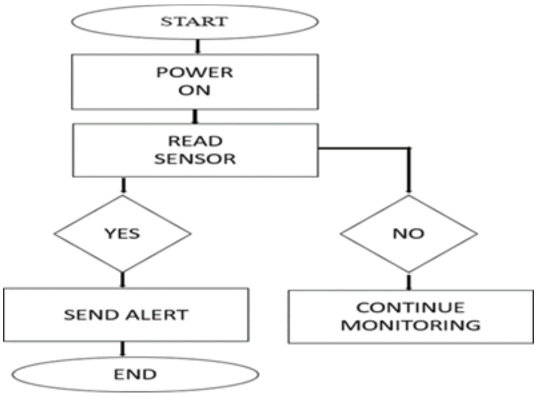

Fig 4.1 Flow Chart of Proposed Method

4.2 SCHEMATIC DIAGRAM

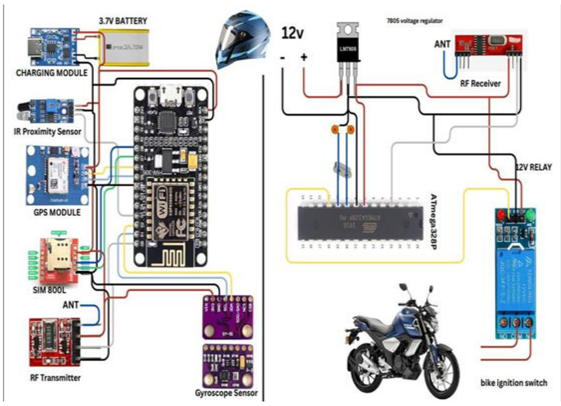

Fig 4.2 Schematic Diagram of Proposed Method

V.RESULTS

The smart helmet system was successfully designed and tested for rider safety applications. The IR sensor correctly detected helmet usage and allowed bike ignition only under safe conditions. The gyroscope sensor effectively identified sudden movements related to accidents. The GPS module accurately provided real-time location details during emergency situations. Alert messages were successfully sent through the GSM module to predefined contacts. Wireless communication between helmet and bike units operated reliably using RF modules. The relay controlled the vehicle ignition system as expected based on safety inputs. Overall, the system showed dependable performance in improving rider protection and emergency response.

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Fig Connections of Helmet Before Switch ON

The above figure shows about the connections of the helmet as the components are interconnected using jumper wires to enable communication between the controller, GPS module, and wireless transmitter.

Fig When Switch ON

The above figure shows the after switch ON when the rider is ready to ride a bike and the connections get starts activate the GPS module and SIM module to run the process.

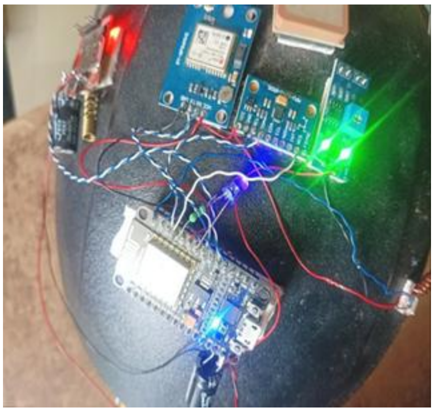

Fig IR Proximity Detected

When the rider kept helmet, IR Proximity Sensor detects it and then only bike will start. The above sensor shows two green lights ON that means the rider kept helmet.

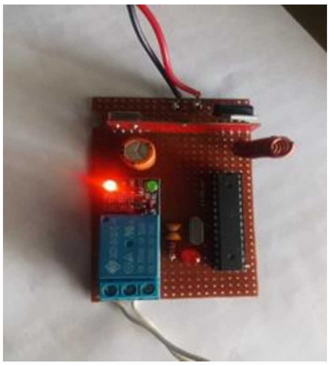

Fig When bike Circuit ON

This shows that circuit of bike that connects to the ignition switch of bike. When we keep charging then relay light will ON as shown in above.

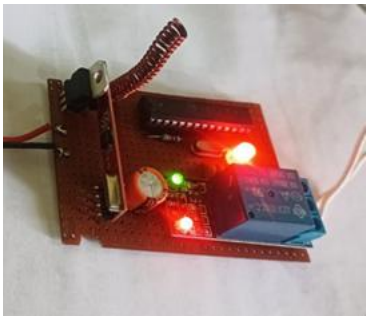

Fig LED ON when helmet kept

The above figure shows that the LED will ON when the rider keeps helmet. This means that the final result is when the rider keeps helmet then only bike will start, instead of bike we used the LED to check results.

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Fig Accident alert message

When the rider gets accident due to the gyroscope sensor detects the position of helmet and immediately sends alert message with location of the rider for particular numbers.

VI.CONCLUSION AND FUTURE SCOPE

The Smart Helmet with Accident Detection and GPS Control using NodeMCU ESP8266 provides an effective and intelligent solution to enhance the safety of two-wheeler riders by integrating sensor-based monitoring, real-time accident detection, and automated emergency communication. The system ensures helmet usage before vehicle operation, continuously tracks rider motion to identify accident conditions, and instantly sends location-based alerts to emergency contacts, thereby significantly reducing response time and improving survival chances. The combination of IoT technology, wireless communication, and embedded systems makes the solution reliable, cost-effective, and suitable for real-world deployment. In the future, the system can be further enhanced by integrating cloud connectivity and mobile applications for real-time monitoring, incorporating artificial intelligence for predictive accident analysis, adding health monitoring sensors such as heart rate and temperature, enabling voice assistance and navigation features, and adopting solar charging for improved energy efficiency, ultimately transforming the smart helmet into a comprehensive intelligent safety and monitoring system for advanced transportation environments.

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