

Smart Safety Helmet Using ESP32

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ABSTRACT

The design and evaluation of Smart Safety Helmet using ESP32 focuses on improving industrial worker safety by integrating Internet of Things (IoT) and embedded systems technology. Workers in construction sites, mining areas, and industrial environments are exposed to hazardous gases, high temperature, and accidental injuries that can lead to serious damage or loss of life. Traditional helmets provide only physical protection and lack monitoring capabilities. The proposed smart safety helmet integrates ESP32 microcontroller, gas sensor, temperature sensor, GPS module, and buzzer to monitor environmental and safety conditions in real time. The ESP32 collects sensor data and sends alerts to supervisors through wireless communication, ensuring quick emergency response. The system detects hazardous gas leakage, high temperature, and accident conditions and activates warning signals to protect workers. GPS module provides real-time location tracking, improving emergency management. The proposed system enhances industrial safety, reduces accidents, and ensures continuous monitoring of worker conditions. The evaluation of the system shows reliable performance in hazardous environments with accurate sensor detection and fast response time. The smart safety helmet is cost-effective, energy efficient, and suitable for industrial safety applications. **Keywords:** ESP32, Smart Helmet, IoT, Industrial Safety, Gas Sensor, GPS, Embedded System.

KEYWORDS: Smart Helmet, ESP32, IoT, Road Safety, Accident Detection, Alcohol Sensor, GPS Tracking.

INTRODUCTION

Road accidents are one of the major causes of death and injuries across the world, especially among motorcycle riders. Bikers are more vulnerable to accidents because they are directly exposed to road conditions and lack advanced safety monitoring systems. Many accidents occur due to alcohol consumption, overspeeding, lack of helmet usage, and delayed emergency response. Traditional helmets provide only physical protection and cannot monitor rider condition or send alerts during accidents. With the advancement of Internet of Things and embedded systems, smart safety helmets can be developed to improve road safety and reduce accident risks.

ESP32 microcontroller is widely used in IoT applications because of its built-in WiFi and Bluetooth communication, low power consumption, and high processing capability. Smart safety helmet using ESP32 can monitor rider safety conditions and send alerts in real time during emergency situations. The helmet integrates alcohol sensor, vibration sensor, GPS module, and helmet detection sensor to monitor biker safety and provide emergency alerts. The proposed system helps in accident detection, alcohol monitoring, and

real-time location tracking to improve emergency response. The main objective of this project is to design and evaluate a smart safety helmet for bikers that improves road safety, reduces accidents, and provides quick emergency assistance through IoT technology.

LITERATURE SURVEY

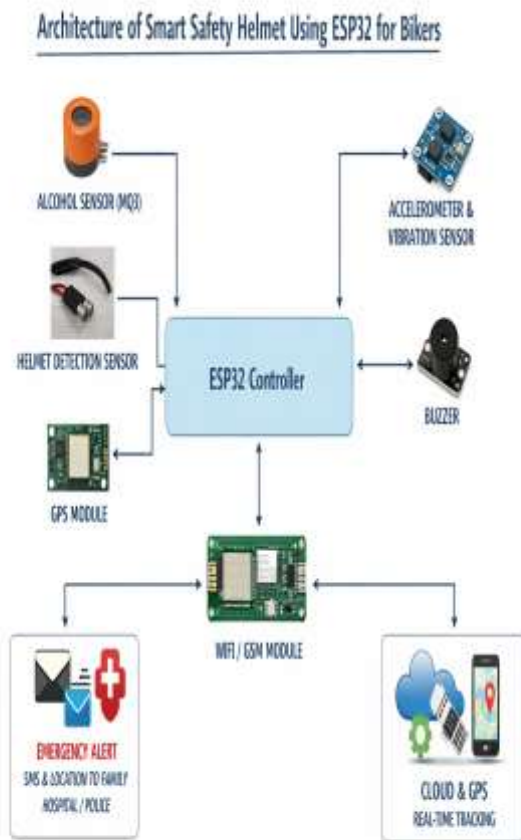
Several researchers have developed smart helmet systems to improve road safety and reduce motorcycle accidents. Earlier research focused on Arduino-based smart helmets with alcohol sensors and GSM modules for sending emergency alerts. These systems were able to detect alcohol consumption and accident conditions and send SMS alerts to emergency contacts. Recent research uses ESP32 microcontroller due to its advanced wireless communication, low power consumption, and real-time monitoring capabilities, making it more efficient for IoT-based smart helmet applications.

Many IoT-based smart helmet systems include GPS tracking and accident detection sensors to monitor rider location and safety conditions. Some systems use vibration sensors and accelerometers to detect accident impact and automatically send alerts to emergency contacts and emergency services. Research studies show that smart helmets can significantly

reduce road accident risks and improve emergency response time by providing real-time monitoring and communication. Several designs also include Bluetooth communication to connect helmet data with mobile applications for continuous monitoring and rider safety management.

Recent studies focus on integrating multiple sensors such as alcohol detection sensors, temperature sensors, and motion sensors to improve safety and provide intelligent monitoring of rider conditions. Some researchers have proposed cloud-based monitoring systems where accident data and location are stored on IoT platforms for real-time tracking and analysis. Advanced smart helmet systems also use GPS and GSM modules to send automatic alerts to family members and nearby hospitals during emergency situations, ensuring quick medical assistance. The use of embedded systems and wireless communication has improved the reliability and performance of smart safety helmets in real-world road conditions. The proposed system improves existing models by integrating ESP32 microcontroller, alcohol detection, accident detection, GPS tracking, and emergency alert system in a compact and cost-effective design suitable for biker safety applications.

Architecture Diagram



PROPOSED SYSTEM

The proposed smart safety helmet using ESP32 for bikers is designed to monitor rider safety and provide emergency alerts during accidents or alcohol detection. The system integrates ESP32 microcontroller, alcohol sensor, helmet detection sensor, vibration sensor, GPS module, and buzzer to monitor biker safety in real time. Sensors continuously collect data and send it to ESP32 for processing and analysis.

If alcohol is detected, the system sends alert messages with GPS location to family members and nearest hospital or police station. If accident occurs, vibration sensor detects impact and ESP32 sends emergency alert with location for quick medical response. Helmet detection sensor ensures that the rider is wearing helmet and buzzer provides warning if helmet is not properly worn.

GPS module tracks location and enables real-time monitoring of biker safety conditions. The proposed system improves road safety by providing continuous monitoring, emergency alert system, and quick response mechanism. The smart safety helmet is compact, lightweight, and energy efficient, making it suitable for real-world biker safety applications.

IMPLEMENTATION

The implementation of the smart safety helmet using ESP32 for bikers is carried out by integrating hardware components and embedded software to monitor rider safety conditions in real time. The system is designed to detect alcohol consumption, accident conditions, helmet wearing status, and location tracking using various sensors connected to ESP32 microcontroller. The ESP32 acts as the central processing unit that collects sensor data, processes it, and sends emergency alerts through wireless communication. The helmet detection sensor is placed inside the helmet to detect whether the rider is wearing the helmet properly and the buzzer provides warning if the helmet is not worn correctly.

The alcohol sensor MQ3 is installed near the mouth area of the helmet to detect alcohol in the rider’s breath and send data to ESP32 for processing. When alcohol is detected above the threshold value, the system activates the buzzer and sends emergency alert with GPS location to family members and nearest hospital or police station. The vibration or accelerometer sensor is used to detect sudden impact or accident conditions and automatically triggers emergency alert system with location tracking. GPS module continuously tracks the location of the rider and provides real-time coordinates to ESP32 for emergency communication.

The ESP32 microcontroller processes all sensor data and sends alerts through WiFi or GSM communication module to emergency contacts. The system is powered by a rechargeable battery and designed to be compact and lightweight so that it can be easily integrated into the helmet structure. The implementation ensures continuous monitoring of biker

safety and provides fast emergency response during accident or alcohol detection. The system is tested under different road conditions to verify sensor accuracy and communication performance, and the results show reliable operation and efficient emergency alert generation.

installed inside the helmet to monitor proper helmet usage. The vibration or accelerometer sensor is used to detect accident impact and GPS module provides real-time location tracking for emergency alerts. The buzzer generates warning signals during unsafe conditions and the communication module sends emergency messages to family members and nearest hospital or police station. The rechargeable battery supplies power to all components and ensures continuous operation of the system, making the smart safety helmet compact, lightweight, and suitable for real-world biker safety applications.

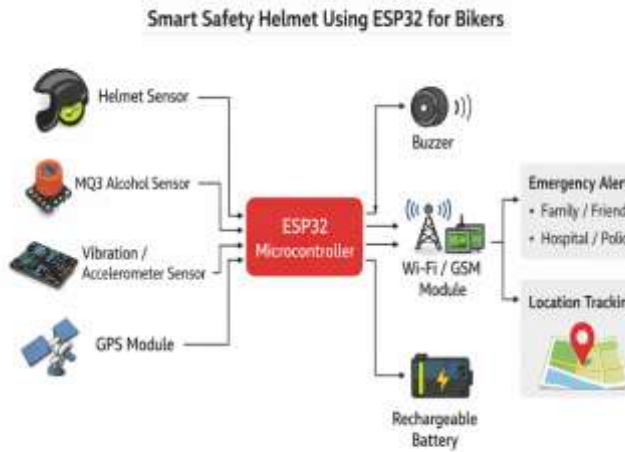


Fig: 1: Block Diagram

The block diagram of the smart safety helmet using ESP32 for bikers shows the functional structure of the system where ESP32 acts as the central controller connected to helmet detection sensor, MQ3 alcohol sensor, vibration or accelerometer sensor, GPS module, buzzer, WiFi or GSM module, and rechargeable battery. The helmet sensor detects whether the rider is wearing the helmet properly, the alcohol sensor detects alcohol in the rider’s breath, and the vibration or accelerometer sensor detects accident conditions. The GPS module provides real-time location tracking and the WiFi or GSM module sends emergency alerts with location to family members and nearest hospital or police station. The buzzer provides warning signals during unsafe conditions and the rechargeable battery supplies power to the system. The block diagram represents the overall working of the smart safety helmet system for improving biker safety and emergency response.

HARDWARE IMPLEMENTATION

The hardware implementation of the smart safety helmet using ESP32 for bikers consists of ESP32 microcontroller, MQ3 alcohol sensor, helmet detection sensor, vibration or accelerometer sensor, GPS module, buzzer, WiFi or GSM communication module, rechargeable battery, and power regulation circuit integrated inside the helmet structure. ESP32 acts as the main controller that connects all sensors and processes real-time data for safety monitoring. The MQ3 alcohol sensor is placed near the mouth area to detect alcohol in the rider’s breath, while the helmet detection sensor is

SOFTWARE IMPLEMENTATION

The software implementation of the smart safety helmet using ESP32 for bikers is developed using Arduino IDE and embedded C programming to control sensors and communication modules. The ESP32 microcontroller is programmed to read data from helmet detection sensor, MQ3 alcohol sensor, vibration or accelerometer sensor, and GPS module and process the data in real time. The program continuously checks sensor values and compares them with predefined threshold levels to detect unsafe conditions such as alcohol consumption or accident impact. When alcohol is detected, the software activates the buzzer and sends emergency alert with GPS location to family members and nearest hospital or police station through WiFi or GSM communication. When accident is detected, the system automatically sends emergency message with real-time location for quick response. The GPS module continuously updates location coordinates and the communication module transmits the data to emergency contacts.

The software ensures continuous monitoring, fast response, and reliable operation of the smart safety helmet system for

improving biker safety and emergency communication.

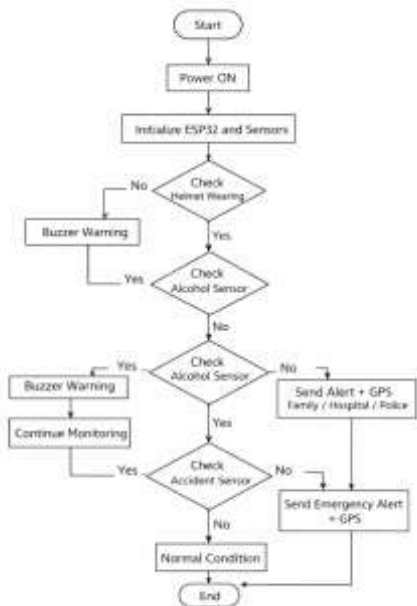


Fig.4 Flowchart of Smart Safety helmet Using ESP32 for Bikers

Fig. 3: Flowchart

CONCLUSION

The design and evaluation of smart safety helmet using ESP32 for bikers provides an effective solution for improving road safety and reducing motorcycle accidents through real-time monitoring and emergency alert system. The system integrates alcohol sensor, helmet detection sensor, vibration or accelerometer sensor, GPS module, buzzer, and wireless communication to monitor rider safety and detect accident or alcohol conditions. ESP32 microcontroller processes sensor data and sends emergency alerts with GPS location to family members and nearest hospital or police station to ensure quick medical response and safety support. The proposed smart helmet is compact, low-cost, energy efficient, and suitable for real-world transportation safety applications. The system improves biker safety by providing continuous monitoring, fast emergency communication, and reliable accident detection, making it a useful solution for modern smart road safety and IoT-based transportation systems.

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