

Ai Integrated Smart Helemt

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Abstract—Two-wheeler riders are exposed to multiple safety risks including non-use of helmets, alcohol-impaired riding, sudden impacts and delayed emergency response after an accident. This paper presents the design of an AI-integrated smart helmet intended to combine preventive safety, accident detection, location tracking and emergency communication in a single wearable system. The proposed architecture uses ESP32 controllers, an IR sensor for helmet-wearing verification, an alcohol sensor, an ADXL-series motion/impact sensor, RF transmitter receiver communication, a relay interface. GPS, GSM and an ESP32-CAM. Tikamcra-based imaging unit. Sensor information is processed at the helmet and vehicle units. The vehicle is enabled only when the received safety status satisfies the defined conditions. When an abnormal impact or accident condition is detected, the camera captures accident evidence. GPS provides the riders location and GSM communicates an emergency alert to predefined contacts. Machine learning is included as the intended intelligent layer for improving accident-risk recognition beyond simple threshold decisions. The proposed system therefore combines sensing, local decision making, wireless communication, visual evidence and emergency notification. The design is motivated by previous smart-helmet research showing the value of multimodal sensing, IoT connectivity and automated alerts, while addressing the need for a more integrated safety architecture.

I. INTRODUCTION

Two-wheeler riders are among the most vulnerable road users, since a helmet is often the only protection between the rider and a serious head injury. Even so, helmet non-use, drunk riding and delayed emergency response continue to turn avoidable incidents into fatal ones. Conventional helmets are passive: they cannot verify whether they are being worn, whether the rider is fit to ride, or whether help has been called after a crash. Advances in low-cost embedded controllers, wireless modules and compact sensors have made it practical to turn the helmet into an active safety device that monitors the rider and the riding condition in real time.

This paper presents an AI-integrated smart helmet system built around the ESP32 microcontroller to improve two-wheeler safety through prevention and rapid response. The helmet unit uses an IR sensor to verify helmet usage, an alcohol sensor to detect alcohol-related unsafe conditions, and an ADXL accelerometer to sense sudden motion or impact. The resulting safety status is sent over an RF link to a vehicle-side ESP32, which drives a relay to enable or disable the vehicle. When an accident or abnormal event is detected, the system captures evidence with an ESP32-CAM, obtains the rider's location through GPS, and sends an alert to predefined contacts through a GSM module. A machine learning layer is proposed to make accident-risk detection more reliable by combining several inputs rather than relying on a single threshold. The rest of the paper is organised as follows: the literature review, the proposed methodology and system architecture, the working principle, and the hardware and software used.

II. OBJECTIVES

The system checks that the helmet is actually on the rider's head and not just carried on the bike. An IR sensor inside the helmet senses the presence of the head, and the ESP32 reads this signal continuously. Helmet non-use is a major cause of fatal head injuries, so checking real usage makes the safety rule meaningful. If the helmet is not worn, the relay stays disabled and the vehicle cannot operate.

The system checks whether the rider is under the influence of alcohol and keeps checking during the ride, not only at the start. An alcohol sensor (MQ-3/MQ-9) measures alcohol in the rider's breath, and the ESP32 compares the reading with a permitted threshold. If the reading is above the limit, the rider is treated as unsafe and the vehicle is kept disabled

through the relay. Since drunk riding reduces reaction time, balance and judgement, this automatic check removes the need to depend on the rider's honesty or on roadside checks.

The system recognizes a crash, fall or sudden unusual movement on its own, without the rider pressing any button. This is important because a seriously injured rider may be unconscious. An ADXL accelerometer measures acceleration in three directions, and a sudden large change indicates a possible impact or fall. When this happens, the ESP32 activates the emergency path, so this objective is the starting point for the camera, GPS and GSM modules.

After an accident, the exact location reaches the people who can help, such as family members. The GPS module finds the rider's latitude and longitude, and the GSM module sends it in an alert message to numbers stored in advance. Accident victims often cannot call for help or explain where they are, especially on roads with little traffic, so a location sent automatically saves the time spent searching.

The system records what the scene looks like so that the alert says more than "an accident happened". When an accident is detected, the ESP32-CAM takes a snapshot or video, which supports the alert sent through the GPS and GSM modules. The image helps the contacts and responders judge how serious the situation is and what help to send. It also serves as a record of the event for later checking.

A fixed threshold simply says that an acceleration above a set value is an accident, which is easy to implement but unreliable. A machine learning layer looks at several inputs together, such as motion patterns, alcohol status and, where available, camera information. It can be trained on labeled examples of normal riding, braking, potholes and accidents. This aims to reduce false alarms from potholes or hard braking and to avoid missing real but less sharp falls. Your paper correctly states that this layer is proposed and that no trained model or measured accuracy is reported yet

This is the overall goal that the other objectives support: the time between the accident and the arrival of help should be as short as possible. Everything happens automatically in a chain of detection by the ADXL sensor, evidence from the camera, location from the GPS and the alert from the GSM module, with no human action needed in between. In serious accidents the first minutes decide the outcome, so

removing the wait for a passer-by to notice and call for help improves the rider's chances. Preventing unsafe riding in the first place, through the helmet and alcohol checks, further improves the overall safety response.

III. PROBLEM STATEMENT

Existing low-cost smart-helmet implementations frequently rely on individual sensor thresholds. Although such methods are simple and fast, sudden braking, potholes, vibration and other normal riding events can produce sensor patterns similar to an accident. At the same time, a system that detects an accident but does not rapidly transmit location and evidence has limited usefulness during a real emergency. The project therefore addresses the following problem: how can a wearable helmet and vehicle unit integrate preventive safety checks, abnormal-motion detection, wireless communication, location tracking and accident imagery so that unsafe operation can be restricted and emergency information can be transmitted automatically? The proposed work also introduces an AVML layer as a pathway toward more reliable accident-risk recognition.

IV. METHODOLOGY

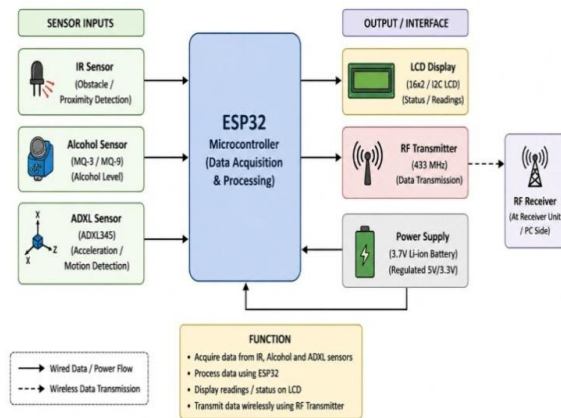
The proposed system is divided into two units: a helmet unit (transmitter side) and a vehicle unit (receiver side). The helmet unit checks the rider's condition and the riding situation, and the vehicle unit decides whether the vehicle may run and handles the emergency response. Both units use an ESP32 microcontroller, and the two are linked by a 433 MHz RF connection. The methodology follows five stages: sensing, decision making, wireless transmission, vehicle control, and emergency response.

System Architecture

The architecture is divided into two nodes. The helmet node performs sensing and first-level decision making, while the vehicle node receives the safety status and handles vehicle control and emergency coordination. This separation avoids placing every module on the helmet, which keeps the helmet light and comfortable. It also gives a clear RF

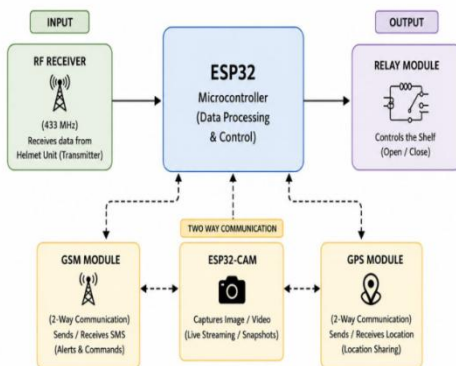
communication boundary between the rider and the vehicle.

Helmet unit: The ESP32 acts as the central controller and collects data from three sensors. An IR sensor checks whether the helmet is worn. An alcohol sensor (MQ-3/MQ-9) measures the alcohol level in the rider's breath. An ADXL345 accelerometer measures acceleration and detects sudden motion or impact. The ESP32 shows the safety state and sensor readings on a 16x2 I2C LCD and sends the status through an RF transmitter. The unit is powered by a 3.7 V Li-ion battery with regulated 5 V and 3.3 V supplies.



Vehicle unit. A second ESP32 receives the data through an RF receiver and checks the rider's safety state. Its output goes to a relay module that enables or disables the vehicle. A GPS module, a GSM module and an ESP32-CAM are connected to this ESP32 for emergency response, with two-way communication between them.

**RECEIVING SIDE BLOCK DIAGRAM
(VEHICLE UNIT)**



After power-up, the helmet ESP32 initializes all sensors and reads them continuously. The IR sensor gives a helmet-worn or helmet-absent signal. The

alcohol sensor gives an analog reading that is compared with a permitted project threshold. The ADXL345 gives acceleration values which are used to find abnormal motion or impact.

The ESP32 checks three primary conditions together:

1. The helmet is worn.
2. The alcohol reading is within the permitted threshold.
3. No abnormal motion or impact is detected.

If all three are satisfied, the rider is marked as safe. If the helmet is not worn or alcohol is detected, the rider is marked as unsafe and the vehicle must stay disabled. If abnormal motion or impact is detected, the system treats it as a possible accident and starts the emergency process.

The vehicle ESP32 first validates the received data and then controls the relay. When the status is safe, the relay is activated and the vehicle mechanism can operate. When the helmet is absent or alcohol is detected, the relay remains disabled and the vehicle cannot be used. This makes the safety rule an actual control action and not just a warning.

When an accident or abnormal event is detected, the emergency path is activated in three steps:

1. The ESP32-CAM (or IP camera) captures an image or video of the scene as evidence.
2. The GPS module obtains the rider's current location.
3. The GSM module sends an alert with the location to predefined emergency contacts.

A buzzer and the LCD also give local warning indications. After the event, continuous monitoring allows the system to return to the normal safety-check cycle.

The AI/ML layer of the proposed system is based on the ESP32-CAM. The camera captures images of the scene, and a machine learning model analyses them to identify signs of an accident or abnormal event. This visual result is combined with the acceleration reading from the ADXL sensor and the helmet status, so the decision does not depend on a single fixed threshold. Using several inputs together helps reduce false alarms caused by events such as potholes or sudden braking, and helps detect real accidents more reliably. When an accident is confirmed, the system captures the evidence image, obtains the rider's location through GPS and sends an alert to predefined emergency contacts through the GSM module.

Software Implementation

The software of the proposed system is developed using the Arduino IDE and uploaded to the ESP32 controllers. Two separate programs are used. The helmet-side program initialises the IR, alcohol and ADXL345 sensors, reads them continuously, checks the safety conditions, displays the status on the LCD, gives warnings through the buzzer, and transmits the safety status through the RF link. The vehicle-side program receives and validates this status and controls the relay, which enables the vehicle only when the helmet is worn and no alcohol is detected. When an accident or abnormal event is detected, the program activates the emergency routine, in which the ESP32-CAM captures an image or video, the GPS module obtains the rider's location, and the GSM module sends an alert to predefined emergency contacts. The AI/ML component, based on the ESP32-CAM, analyses the captured images and combines the result with the sensor readings to improve accident detection. After each event, the system returns to the normal safety-check cycle.

V. CONCLUSION

The proposed AI-integrated smart helmet combines preventive rider checks and post-accident response in one architecture. Unlike a helmet that only detects an impact, the system links helmet verification, alcohol monitoring, motion sensing, RF communication, vehicle control, GPS, GSM and camera—based evidence. The architecture is consistent with the direction of smart-helmet research toward multimodal sensing and connected safety services. The project is presently a design/prototype stage system; therefore, quantitative claims about accident-detection accuracy, response time or ML performance should only be reported after controlled experiments. The main technical contribution of the proposed design is the integration of multiple safety functions with an intended AI layer that can later be evaluated against threshold & based

VI. FUTURE SCOPE

The present system can be improved in several ways to make accident detection more accurate and reliable. A machine learning classifier can be trained and validated using labelled data from normal riding,

sudden braking, potholes and accidents, so that it learns to tell these events apart instead of relying on fixed thresholds. The motion data from the ADXL sensor can be combined with the images from the ESP32-CAM, so that an alert is sent only when both indicate a likely accident, which reduces false alarms. A short waiting period can also be added before the emergency message is sent, where appropriate, so that the rider can cancel the alert after a minor fall, while an unresponsive rider still receives help automatically.

The emergency communication and monitoring features can also be strengthened. The reliability of the GPS and GSM modules can be evaluated under weak-signal conditions such as tunnels, hilly areas and crowded places, and the delay in finding the location and delivering the message can be reduced. A cloud or mobile dashboard can be developed to show the rider's live status, location and event history, which will make the system more useful than SMS alerts alone. Power management can be improved to increase battery life, and rechargeable and solar-assisted operation can be investigated to reduce the need for frequent charging.

Finally, the complete system should be tested through controlled laboratory and road trials, measuring precision, recall, false-alarm rate and response time, so that its performance is supported by measured results. The electronics can also be made smaller, and the enclosure, wiring and weather protection can be improved, so that the system is comfortable for the rider and works reliably in rain, dust and vibration. These improvements would move the project from a working prototype toward a practical and dependable rider-safety product.

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