SMART CASQUE

A smart helmet for ensuring rider sobriety and safety

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Abstract – The Smart Casque initiative represents an innovative safety solution aimed at enhancing the protection of two-wheeler riders through the integration of advanced sensors and wireless technology within a helmet and motorcycle system. This system enforces mandatory helmet usage and assesses alcohol consumption prior to enabling the motorcycle engine, thereby mitigating unsafe riding behaviours. It continuously monitors the rider's condition and the vehicle's status via a wirelessly connected helmet and motorcycle module. In the event of an accident, the system employs an accelerometer to detect a crash, which subsequently triggers the GPS module to ascertain the rider's precise location and dispatch emergency alerts to predetermined contacts for prompt assistance. By amalgamating real-time monitoring, automated engine control, crash detection, and immediate alerts, the Smart Casque contributes to the reduction of accidents, the prevention of drunk driving and vehicle theft, and significantly enhances overall road safety, particularly in high-risk areas.

Keywords- *Ultrasonic Sensor, ESP32, GPS Module*

I. INTRODUCTION

Technology is deeply integrated into every aspect of our daily lives, influencing areas such as education, manufacturing, transportation, communication, and healthcare. The transportation sector, in particular, is vital to the economy and serves as an essential tool for governments globally. Among the various transportation options, motorcycles have become increasingly popular, especially among younger individuals. Despite their attractiveness, motorcycles present significant safety hazards. Their open structure makes riders susceptible to harm, and even minor distractions can lead to serious injuries or fatalities.

Several factors affect motorcycle safety, including the vehicle's design, the type of safety gear used, and the rider's proficiency. Major risks involve speeding, reckless behaviour, alcohol use, and traffic infractions. A significant factor contributing to severe injuries and deaths is the

failure to wear helmets. Research indicates that helmet use can decrease the risk of head injuries by 80%, greatly enhancing the likelihood of surviving an accident. To improve motorcycle safety, modern technologies like the Internet of Things (IoT) can be instrumental. By outfitting motorcycles with sensors and alert systems, we can boost rider awareness, improve communication, and

enforce helmet usage. Our project seeks to tackle these issues by concentrating on "Rider's safety," which includes creating a helmet that not only safeguards riders but also

addresses problems related to impaired driving. The system will verify if the rider is wearing a helmet; if so, the vehicle will start, and it will also check for alcohol consumption. If the rider is sober, the motorcycle will operate without any hindrance.

II. PROBLEM DEFINITION

In nations such as India, a significant portion of daily travellers rely on two-wheelers like motorcycles and scooters because they are both affordable and convenient. Unfortunately, this extensive use has resulted in a high incidence of road accidents, injuries, and deaths. Despite the presence of stringent traffic regulations and safety awareness initiatives, many riders fail to adhere to fundamental safety measures, such as properly wearing helmets and observing road safety guidelines. Conventional helmets primarily provide impact protection and do not address other critical factors contributing to accidents.

Besides the issue of safety, the problem of vehicle theft is also a concern, as most two-wheelers do not have sophisticated security systems. The rider also encounters problems such as poor situational awareness, the absence of real-time monitoring, and the lack of immediate assistance in case of an accident. These problems highlight the shortcomings of the traditional system of riding and the need for a smarter and more reliable safety solution.

Drunk driving is among the major causes of death in accidents, but the normal helmet does not have the ability to detect drunk
driving or prevent a drunk motorist from operating the vehicle. Additionally, there is no way to ensure the usage of the helmet and alert the relevant parties in case of an accident. In most cases, delayed medical care in an accident leads to severe injuries or death.

Human error, as a result of fatigue, distractions, and negligence, increases the chances of accidents that conventional helmets would not be able to identify or prevent. In some instances, accidents occurring in rural areas may remain undetected for an extended period of time leading to delayed treatment and increased fatality rates.

III. EXISTING SOLUTION

Sena SmartHelmet: Offers sophisticated communication features, such as intercoms for group communication.
Quin Design Helmets: These helmets have crash detection features that enable the automatic sending of notifications to pre-set contacts.
Nuviz HUD: This is an accessory device that is mounted on helmets and provides information to the rider within his direct line of sight.
Skully AR-1: One of the first smart helmets to feature a rear-view camera; the company ceased operations.
Brake Free: An attachable smart brake-light system located at the back of the helmet, which indicates braking to the vehicles behind.
Axor Helmets: Known for their innovative designs in helmets, such as smart helmets that incorporate Bluetooth communication systems and GPS navigation.

IV. METHODOLOGY

A helmet module utilizes two basic input sensors (alcohol sensor and ultrasonic) to verify that the rider is safe before allowing the engine to start. An alcohol sensor located at the chin area checks the rider's breath for presence of any alcohol. The ultrasonic sensor tests if the helmet is on securely by measuring the distance from the sensor to the rider's head. The system determines the rider is safe only after determining both readings are within a safe limit (i.e., alcohol level is OK and ultrasonic distance is OK). The ESP32 processes these inputs and generates a wireless signal back to the bike module granting it permission to start.

On the bike side, the system includes a relay, MPU6050 accelerometer, and GPS module. The relay serves as the output device used to turn the engine ON/OFF. The relay only turns ON when the ESP32 receives a safe input from the helmet. The bike will not start if either the helmet is not being used properly or there is a high level of alcohol.

To detect accidents while riding, the MPU6050 accelerometer is used as the only means of sensing sudden deceleration or collision. It records information regarding all three axes of acceleration on the X, Y, and Z-axes, as well as all three axes of braking. If an accident occurs, the accelerometer will sense a large spike in magnitude due to the sudden deceleration or collision and will send this value on to the ESP32 as the impact value.

Once an accident has been detected, the system will automatically turn on the GPS module, which would

otherwise be turned off during normal riding mode in order to conserve battery power, in order to capture the exact coordinates of the accident site. The stored coordinates can then be sent via Wi-Fi from the ESP32 to the user's designated emergency contacts as a notification via either email or WhatsApp. Future enhancements to the system may involve developing a subscription-based app for mobile devices that would send notifications through either email, WhatsApp or the app itself.

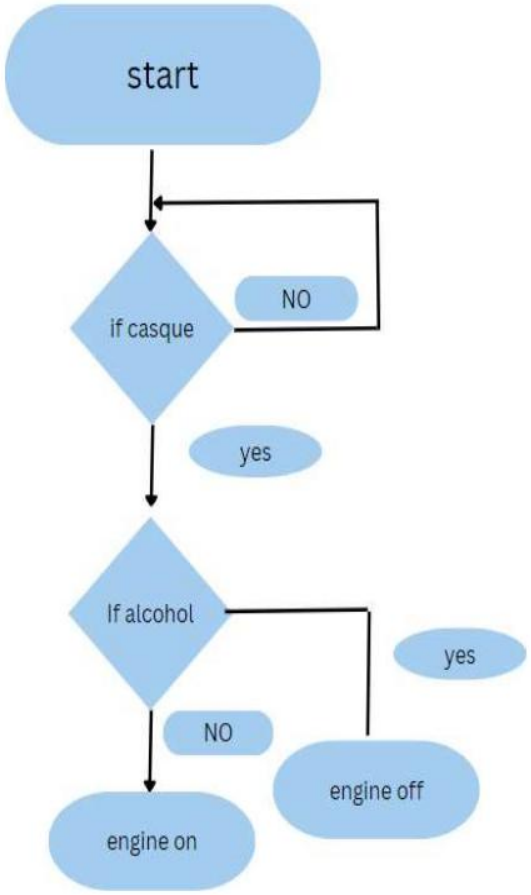

Figure 1: Work Flow

V. MODULES

Helmet Section :

Smart Casque system takes an initial measure through the helmet module, which controls the ability to start the bike based on the state of safety of the rider. The helmet module contains a pair of sensors, represented in the adjacent diagram. One of the sensors is an alcohol sensor, which is aimed at the rider's mouth and detects alcohol in their breath. If a rider exceeds a pre-set alcohol safety threshold, they will be considered unsafe by the Smart Casque. The second sensor is a distance sensor, also known as an ultrasonic sensor, and is used to confirm that the rider is wearing the helmet properly. Measured distance between the helmet and the head reflects whether the helmet has been placed on the head correctly.

Once both sensor readings have been taken, the ESP32 will analyze the inputs to confirm that both required conditions (low alcohol level and proper helmet placement) are met and then send a wireless authorization signal to the bike module to authorize the start of the bicycle. If either or both conditions are not satisfied, a wireless authorization signal will not be transmitted to the bike module keeping the unsafe rider from starting the bike.

Bike Section :

The "Bike Section" contains four components (a relay, an MPU6050 accelerometer, a GPS module, and a battery pack). The Relay controls the connection to the engine's ignition system. Once the ESP32 receives a "safe" signal from the Helmet module, the Relay connects to supply power to the engine, which allows the engine to operate. However, if the Rider is intoxicated or not properly using the helmet, the Relay will not connect, thus preventing the engine from operating.

When riding, the Accident Detection function is assigned to the MPU6050 Accelerometer. The MPU6050 monitors the Rider's acceleration and orientation on the X-, Y-, and Z-axes. If a Collision/Impact occurs, the MPU6050 will detect an immediate change in the Rider's motion, indicating that an accident has occurred. The crash data is sent from the MPU6050 to the ESP32, which will then initiate the GPS module. The GPS modules will typically remain powered-off when not being used for economy reasons. Once activated, the GPS module will determine the latitude and longitude of the accident. The coordinates obtained by the GPS module are wirelessly transmitted via Wi-Fi to send emergency alerts to pre-identified emergency contacts by email or WhatsApp. This automated system ensures that the contact list receives a quicker response and will improve Rider Safety. Future Enhancements will include Mobile App Notification support. *Figure 2: Architectural Diagram*

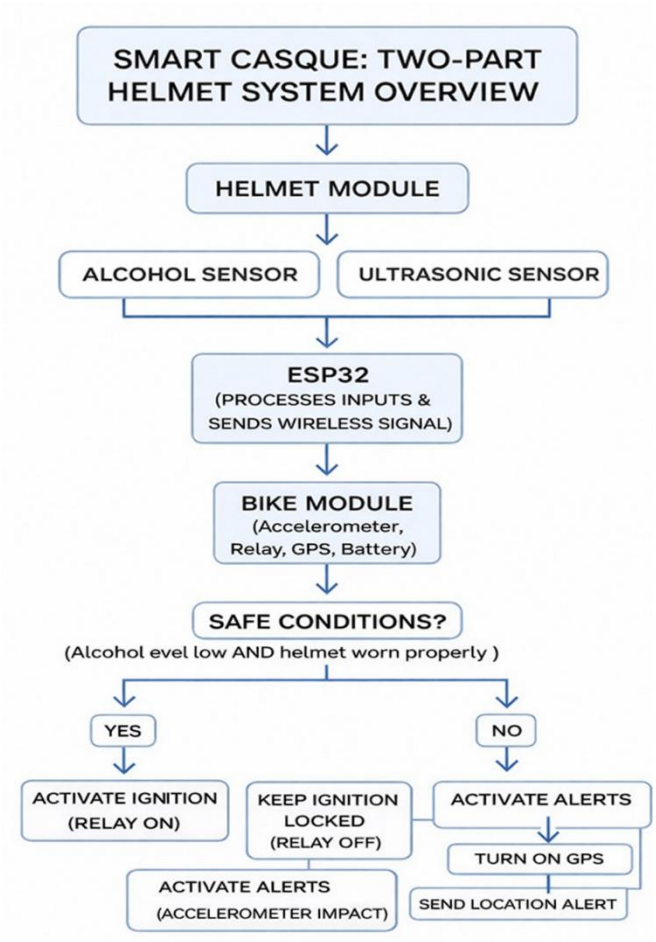

Figure 2: Architectural Diagram

VI. SYSTEM IMPLEMENTATION

Smart Casque System is being implemented into a prototype of a helmet and a simulated bike ignition control circuit, using the hardware devices needed to complete the system's hardware component integration. There are two main components in the system; the sensing part of the helmet and the controlling and safety component of the bike (both of which are powered/operated using a ESP32 microcontroller).

On the helmet side of the smart casque helmet system, there are two principal sensing devices mounted to the helmet for monitoring the riding conditions. The first of these is an ultrasonic sensor, located inside the helmet, which measures the length of the distance between the sensor and the rider's head, and thus checks how well the rider is fitting into the helmet. The second is an alcohol sensor, placed near the rider's mouth to determine if there is an amount of alcohol present in the rider's breath. Both sensors are wired to the ESP32 input pins and powered from a compact, rechargeable battery located at the rear of the helmet. The ESP32 processes these sensor readings in real-time, and then will generate a warning signal for the bike module concerning the rider's safety.

The bike component consists of an MPU6050 accelerometer, a relay, and a GPS module. The ESP32 output pin directly controls the relay and hence serves as the ignition lock for the bicycle. In its default condition, the relay remains in an OFF condition so as to stop operation of the engine. In this initial state, the relay will be activated and switch into an ON condition when the helmet has been worn correctly and the blood alcohol reading is within the safety limits of the manufacturer. The MPU6050 accelerometer continuously monitors the three axes of acceleration (X, Y, and Z) for rapid and large changes in acceleration values, like when someone crashes into or

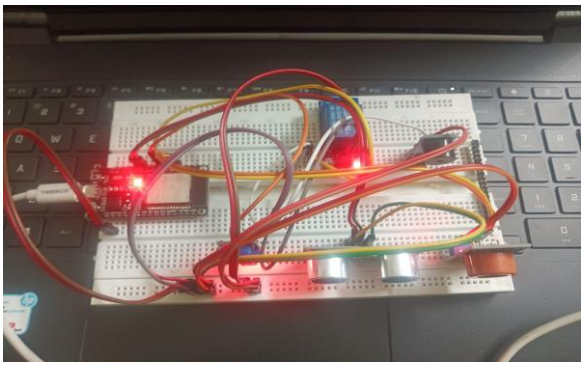

Figure 3. Model Setup

The GPS module will remain OFF and only operate when the accelerometer detects an unusual amount of force, thus optimally conserving battery life. During a simulated crash, the GPS module obtains the precise GPS coordinates of the accident and sends them via email or by WhatsApp over a Wi-Fi-based alert system using a ESP32.

We can simulate various riding conditions (for example, using a helmet while riding normally, or not wearing a helmet; detecting alcohol; safely riding; simulating a crashing fall) and monitor the sensors' output and decisions made by the prototype. All monitoring and validation occur in real-time via the serial monitor.

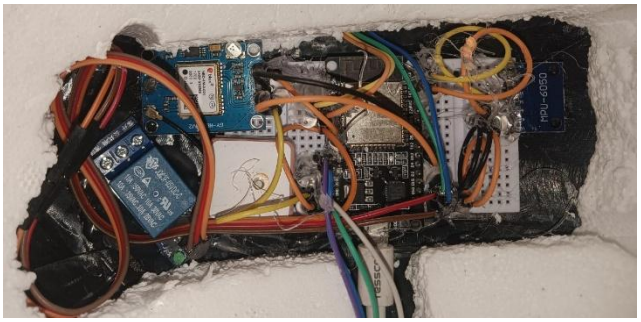

Figure 4. Implementation

The modular nature of our experimental configuration provides easy avenues for further development (e.g., mobile app integration; subscription services to send emergency alert notifications). The integration of such features with IoT capability allows us to demonstrate the viability of the Smart Casque system and verify that it provides a means of safely controlling ignition and detecting crashes in real time.

VII. CONCLUSION

The Smart Helmet System is designed to greatly improve the overall safety of two-wheeled riders as it addresses three major contributing factors to rider accidents, including alcohol use, fatigue, and improper usage of helmets. By including alcohol sensors, vibration sensors and head position sensors in conjunction with wireless communication technology, this solution is designed so that once the rider is determined to be in a safe condition, the bike will only start. Furthermore, by allowing users to provide emergency alerts and track real time locations, the Smart Helmet System creates opportunities to respond more rapidly in emergency situations such as motorcycle accidents. With the ability for integration into daily transportation methods, the Smart Helmet System will foster responsible behavior on behalf of riders and is capable of continued growth and expansion within the future.

VIII. FUTURE ENHANCEMENT

Integration Of Drowzy Detection: Future versions of the system may contain a drowsy detection mechanism; with the potential use of eye-tracking or facial recognition technologies to evaluate the alertness levels of a rider in real-time and provide an additional layer of safety.

Cloud Connectivity And Data Analyses: The integration of cloud services utilizing the data collected by the helmet system may assist in identifying riding behaviour patterns and provide feedback on the frequency of use as well as other critical aspects of riding behaviours. Insurance companies can use the data with riders demonstrating safe riding practices to determine an associated discount.

Integration With Traffic Monitoring Systems/Technology: The helmet system has the potential to be connected to citywide traffic monitoring systems, allowing riders to receive up-to-date information about traffic delays,

accidents, and road closures along their routes.

Improving Battery Life, Size, Weight: Future work will likely focus on extending the battery life of the sensors and wireless communication modules, along with reducing the size and weight of the helmet sensor system to optimize the comfort of the rider.

Collaboration with Bike Manufacturers: Work with bike manufacturers could allow smart helmet systems to be integrated with new bicycles at the point of manufacture, making the collection of technology more easily available to consumers.

Accident Prediction Algorithms: Future research into the development of predictive algorithms could lead to sensors collecting data that could be used to develop algorithms that can predict when a potential accident may occur and to notify the user before the accident occurs, and/or to prevent the bike from starting if the risk is too great.

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