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Helmassist: A Smart Helmet System For Motorcycle Riders With Real-Time Fall DetectionAnd Helmet Safety

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***Abstract*—Helmassist is a comprehensive system that leverages the capabilities of a smart motorcycle helmet and a user-friendly mobile application to provide an array of safety and convenience features for riders. The smart helmet integrates seamlessly with the mobile app to offer a hands-free solution for managing calls while riding, ensuring that riders can stay connected without compromising their safety on the road. Additionally, the helmet can receive and notify important notifications, allowing riders to stay informed without having to check their phones.One of the key safety features of Helmassist is its speed warning system, which alerts riders when they exceed predetermined speed limits, helping them maintain safe and legal speeds. The system also provides real-time weather alerts, giving riders the information they need to plan their rides and take raincoats so that they can stay safe in changing weather conditions. In the event of an emergency, such as an accident or a medical issue, the helmet's emergency SOS feature can automatically call for help, potentially saving lives.**

Helmassist also includes several innovative security features, such as bike tracking and theft prevention. The system allows riders to track the location of their bike, making it easier to recover in case of theft or loss. Additionally, Helmassist can detect the presence of alcohol, discouraging riders from getting on the road under the influence. The helmet lock detection feature ensures that the helmet is securely locked when in use, preventing major harms in accidental falls.Despite its advanced features, Helmassist is designed to be cost-efficient, making it accessible to a wide range of riders. Overall, Helmassist provides a safe and convenient way for motorcycle riders to use their helmets, enhancing their overall riding experience while prioritizing safety.

***Index Terms*—Smart Helmet, Alcohol Detection, Rider Safety, Accident Prevention Internet of Things, Global Positioning System, Real-Time Crash Detection, Sensors, Emergency Notification, Tracker, Anti-Theft System**

I. Introduction

Wearing helmets while riding motorcycles is crucial not only for individual safety but also for promoting a culture of responsible riding. Helmets act as a shield against traumatic head injuries, which are often the most severe consequences of motorcycle accidents. The protective shell absorbs and disperses impact energy, reducing the risk of life-threatening injuries to the brain. Moreover, they serve as a visible symbol of responsible motorcycling, influencing behavioural norms within the riding community. Despite these critical advantages, there are challenges related to helmet usage, such as discomfort, inconvenience, and resistance from riders. The Helmassist project aims to address these challenges by not only emphasising the importance of wearing helmets but also enhancing the overall riding experience. By introducing features like hands-free calling, emergency SOS, and smart notifications, Helmassist not only reinforces the safety aspect of helmets but also makes them more user-friendly and integral to the modern rider's lifestyle. This project seeks to bridge the gap between safety and convenience, fostering a positive shift in the perception of helmets as indispensable accessories for every motorcycle journey. Ultimately, Helmassist endeavours to contribute to a safer and more responsible riding culture by highlighting the dual significance of wearing helmets – as a fundamental safety measure and as a gateway to a smarter and more connected riding experience.

II. Literature Survey

The creation of a real-time helmet-mounted device for tracking hazardous gases in small areas is discussed in the research paper[1]. The methane, hydrogen sulphide, ammonia, and carbon monoxide concentrations as well as ambient factors like temperature, humidity, and oxygen level are all measured by the system using Alphasense gas sensors. The study addresses the need for accurate and efficient toxic gas monitoring in confined spaces to enhance worker safety and reduce accidents. Existing monitoring systems using MQ-series gas sensors and Wi-Fi or GSM modules have limitations in terms of efficiency, battery utilization, operating life, and interference. The study aims to overcome these limitations by developing a helmet-mounted system that integrates Alphasense gas sensors and other components. The study describes the materials and methodology used in developing the helmet-mounted system. Alphasense NH3-B1, CH-D3, CO/H2S-D2, and O2-A3 gas sensors were utilized, along with a DHT11 temperature and humidity sensor, HC-05 Bluetooth module, and Arduino Mega microcontroller.

The research paper[2] encompasses the collection of data via video recording, the creation and verification of models, and the assessment of the outcomes.A series of movies featuring people wearing and not wearing helmets is part of the research project. A GoPro camera installed on a motorbike was used to record the videos. The dataset featured a variety of helmet types and was evenly distributed between the two classes. CNNs, a type of deep learning approach that works well for image identification applications, were used to train the model. The model's performance was assessed through the use of metrics like precision, specificity, sensitivity, and accuracy. The study's findings demonstrated the proposed model's promising performance, with a 97.24% real-time accuracy rate in identifying helmet wear. When the model's performance was compared to related works, it showed that it could distinguish between motorcyclists wearing helmets and those who did not.

The creation of a smart helmet prototype employing artificial intelligence (AI) for the Industrial Internet of Things (IIoT) is presented in the paper[3]. The sensors on the helmet allow it to continuously assess threats and keep an eye on the working environment. An AI-driven platform is utilised for the analysis of the gathered data. In the study's comparative comparison of supervised learning models, the Convolutional Neural Network (CNN) came out on top with a cross-validation accuracy of 92.05%. The goal of the project is to develop a smart helmet that can measure multiple parameters, including force, temperature, humidity, atmospheric pressure, axis changes, air quality, and luminosity. The goal of the helmet is to enable quicker accident response in industrial settings.The dataset used in the study is made up of 11,755 samples that were taken from actual settings with various risk scenarios. The Things Board platform is used to analyse the parameters that were gathered from the sensors.

The creation of a proximity warning system (PWS) based on smart helmets is presented in the paper[4] as a way to increase road safety, particularly in wide spaces and construction zones. With an integrated Wi-Fi camera and an Arduino Uno board, this smart hat takes pictures and transfers them to a smartphone for evaluation. The Arduino receives a signal through Bluetooth when it detects a car or other vehicle in the picture, and it uses an LED strip with three-color LED's to display an alert. An Arduino Uno board, an ESP 32-CAM camera module, an HC-06 Bluetooth module, LED light strips, and three-color LED's make up the smart helmet. Batteries that are portable supply power. The smartphone receives images taken by the camera module via Wi-Fi for processing. To identify potentially harmful things in visual data, the object detection model is applied. The method measured, in accordance with the guidelines, the minimum diagonal length of the allowable distance from the smart helmet. It was discovered that when the minimum diagonal length rises, the average detection distance falls.

[5] The hardware and software system is designed to monitor the real-time safety situation of cyclists by tracking their current location, tracking their routes, and sending SMS alerts when a crash or collision is detected. This research was conducted on twenty (20) male and five (5) female participants aged between 18 and 40. The Raspberry Pi Zero-W will serve as the Smart Helmet's controller, to which the sensor will be attached. The Arduino secondary controller is mounted on the motorcycle itself, and its function is to transmit the stolen bike's GPS location. With its own GPS module and SMS, the Arduino may function independently of the RPiZero-W. For real-time analysis, sensor data—which includes GPS,accelerometer, alcohol, and crash sensors is transferred to the cloud service interface. For the purpose of writing the scripts for the Raspberry Pi Zero and the Arduino module, the researchers utilised open-source tools such as Python and the Sketch programming language. Regarding cloud architecture, the researchers built up a MySQL server on an EC2 free-tier virtual machine.

[6] The main objective is to address the issue of reminding motorcyclists to drive away from large approaching trucks and buses. The experimental setup involved 10 motorcyclists wearing the proposed intelligent helmet, and each drove a randomized path on a road in Taiwan. Thirty images of rear-approaching large trucks or buses were captured when stopping and waiting for red traffic lights on the cross road ,when wearing the proposed intelligent helmet during day and night conditions. A total of 600 images of rear-approaching trucks/buses on actual roads were used to test the accuracy of the vehicle registration plate recognition. A lightweight image recognition technique is created that can identify the truck or bus's registration plate alone, without its text. In order to identify whether a motorcyclist is approaching an item, such as a huge truck or bus, the detection system uses two infrared transceivers to detect the rider five metres behind. The detected signal will be sent to the MPU and the camera will take a picture of the scene behind the motorcycle if the detected result is less than 5 metres away from the rider. The MPU receives this rear-direction image for image processing and recognition.The helmet was tested with the car's headlights shining directly on it, and the program was found to work normally in such conditions. Test results of the

smart helmet show that the accuracy in real-time identification of large vehicles/buses is up to 70% at night and 75% during the day.The helmet's features include an infrared transceiver, image sensor and embedded computing module, making it a unique and innovative product.

[7]A new modular bike helmet and Arduino Uno-based helmet side, accelerometer, LED array and RF transmitter, which can transmit messages are proposed. The helmet's design included information systems using RF transmitters and LED arrays to communicate with approaching vehicles. The side of the helmet is based on Arduino Uno and a sensor sends a signal to the RF transmitter. The RF transmitter then sends the signal to the LED array, which transmits it to the vehicle. The bike module is limited to an RF transmitter operating at 433 MHz. The bike module should be kept to a minimum due to its simplicity of installation and hassle-free maintenance. There are four ways to control the RF transmission. One control signal is obtained from the brake light and two from the indicator. The helmet features can be activated or deactivated with the fourth signal.The helmet module functions in the following modes and is fueled by a rechargeable power source that is fixed on the helmet.

[8] This paper presents a new method to detect a drunk driver using intelligent detection and tracking learning. The prepared process can reduce the risk of accidents caused by drunk driving. The proposed method uses IoT sensors (such as alcohol sensors and pressure sensors) . The proposed method uses supervised learning to train the model. This information includes features such as alcohol concentration, air pressure and yawning frequency. Deployed neural network models to maximize performance and minimize latency. The performance metrics used to evaluate the system are accuracy, concordance index, and kappa index. Evaluation of the intelligent electronic test model of the generated data, accuracy, consistency and kappa index reached the performance index of 99.8%, 99% and 99.5% respectively. The low inference overhead (2.22 microsecond) makes the system suitable for real-life time use. Preparatory procedures can reduce the risk of accidents caused by drunkenness. The system can be mounted in the vehicle and equipped with a battery (rechargeable) and a small LCD to read the verdict. The system can also be used in off-vehicle alcohol detection applications.The system relies on the accuracy of sensors used to detect alcohol concentration and air pressure. The system will not detect the adverse effects of alcohol in drivers who have taken other drugs that affect their ability to drive. The system concept is lightweight and effective in vehicle solutions.

[9] Smart motorcycle helmet for enhanced Rider's comfort and safety, The paper discusses the development of a smart motorcycle helmet, which offers a comfortable and safe riding experience. It highlights the features of the smart helmet, including a Bluetooth controller, solar rechargeable battery, and voice command system. The helmet features a half-face design with a helmet visor and air flow channel, mini speakers, a Bluetooth speaker controller with quick access buttons, an adjustable microphone, and a solar panel for power. The speakers are installed near the user's ears and connected to a waterproof Bluetooth speaker controller. The smart helmet can be used for various applications, such as receiving phone calls, streaming music, receiving turn-by-turn navigation guidance, and communicating with pillion passengers. The virtual assistant on mobile phones can also be used for specific actions. The smart helmet's trickle charge function reduces recharge frequency and eliminates the need for ideal conditions.

[10] Embedded System with Internet of Things for Secure Monitoring of Vehicle Accidents This paper presents a new approach to road safety and security using embedded systems and the Internet of Things. It aims to improve safety for motorcyclists by addressing issues like over-speeding, drunken driving, mobile phone usage, and inadequate safety awareness. The system includes alcohol and shock sensors, a microcontroller, and internet connectivity, detecting alcohol presence and helmet impacts. In case of an accident, information is transmitted to emergency services. The authors emphasise the importance of shared responsibility for road safety at international, national, regional, state, and local levels, recommending adherence to traffic rules and abstinence from drunk driving. The system offers potential benefits such as reduced response time, improved safety, and enhanced security.

[11] A smart helmet with a built-in drowsiness and alcohol detection system,This paper presents a smart helmet with a built-in drowsiness and alcohol detection system, aiming to increase bike rider safety by detecting major causes of accidents and alerting them through an alarm. The helmet unit consists of a main processing unit, EEG sensor, alcohol sensor, Bluetooth module (Sender), and speaker. The bike unit consists of a central processing unit (CPU) and a GSM module. Tested in a custom-built bike simulator, the system detected drowsiness and alcohol consumption with high accuracy and sent a lockdown command. The authors suggest further improvements by adding more sensors to detect other factors contributing to accidents and integrating with existing bike safety systems.

[12] Improving Thermal Comfort in Industrial Safety Helmet Using Phase Change Material Helmet Cooling System Using Phase Change Material for Long Drive [15], This scholarly work introduces a revolutionary method of incorporating phase change material (PCM) into industrial safety helmets. The PCM is packed within a flexible aluminium casing and strategically placed beneath the outer layer of the helmet. This innovative approach aims to revolutionise the design of industrial safety helmets by leveraging PCM's unique thermal properties. The research's experimental investigations show the efficacy of PCM in absorbing and storing excessive heat, significantly mitigating thermal discomfort experienced by workers in high-temperature environments.

III. PROPOSED SYSTEM

The suggested system, which includes a helmet, is made with a number of sophisticated features to meet user demands. The helmet's integrated speaker and microphone guarantee

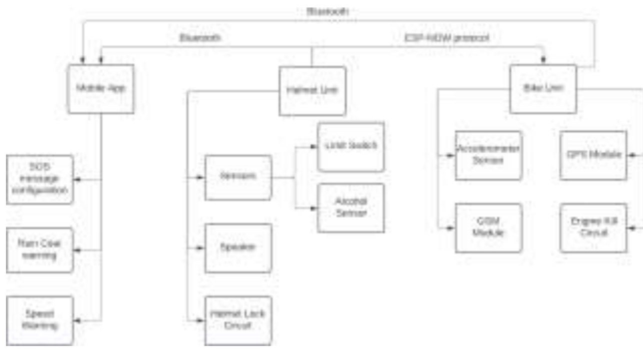

Fig. 1. System Architecture

hassle-free and transparent communication. Long-lasting battery life is ensured by a micro-controller that effectively controls the integrated parts. The gadget, which is enhanced by sensors, offers real-time data for navigation and safety.The sensors embedded on the helmet provides real time information about helmet lock, alcohol presence etc and take actions based on the sensor outputs. A GPS module and antenna provide accurate location tracking, while a Bluetooth module makes for easy wireless connectivity. An intuitive smartphone app that makes setting up the system simple, managing calls efficiently,provide speed warning and weather alerts completes the package. This comprehensive and creative approach aims to reinvent consumer comfort, safety, and communication in a variety of contexts. The proposed system can be divided into 3 modules

A. Modules

1) Helmet: The helmet module consists of a microcontroller-esp32, MQ3 alcohol sensor which is used for alcohol detection inside the rider, limit switch which is used for detecting whether the rider has worn the helmet or not, metallic helmet lock. The metallic helmet can be used to build a circuit that can check if the lock has been locked or not. The data from MQ-3 sensor, limit switch, metallic lock are analyzed inside the esp32 microcontroller and signal is sent to the bike module indicating whether the bike should start or stop. The signals are sent using esp-now wireless communication module. The helmet also includes a bluetooth speaker system that can be paired with the smartphone and use for receiving navigation assistance and also for getting notifications from the bundled mobile applications.

2) Bike: The bike module includes an esp32 microcontroller, NEO-6M GPS module which is used to obtain the location details, SIM800l GSM module which is used to send and receive SMS messages, ADXL345 accelerometer which is used for measuring the orientation of the bike thereby detecting fall, relay which is used for activating and deactivating the ignition circuit inside the bike. The ESP32 inside the bike module communicates with the bike ESP32 and turns the bike on or off. If a fall is detected by the accelerometer for 10 seconds, the ESP32 sends an SOS message using

Fig. 2. Helmet Prototype

sim800l module which includes the coordinates received from the NEO-6M GPS module. The bike is also turned off after detecting a fall. The SIM800l module can also be used to obtain SMS commands for turning the bike off/on in case of bike theft and getting the location of the bike from anywhere without the help of internet.

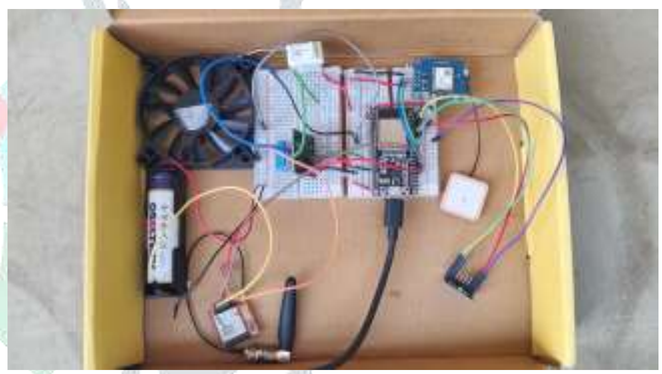

Fig. 3. Bike Circuit

3) Mobile Application: The mobile app developed using the flutter framework is installed inside the mobilephone. It comes with a simple user interface for ease of use. It can be used to turn the bike off/on and show the current location of the bike inside the maps application. The app runs in the background and detects the speed of the rider and gives warning through the bluetooth speaker system inside the helmet if the rider crosses the limit. The app is also able to customize the people's list who should receive the SOS messages in case of a fall or an accident.It also has a feature that assist the rider by checking the weather and reminds the rider to carry a raincoat if rain is expected during their journey.

B. Hardwares and protocols used

1) ESP-NOW: ESP-NOW is a communication protocol developed by Espressif Systems specifically for the ESP8266 and ESP32 microcontrollers. It enables direct, peer-to-peer

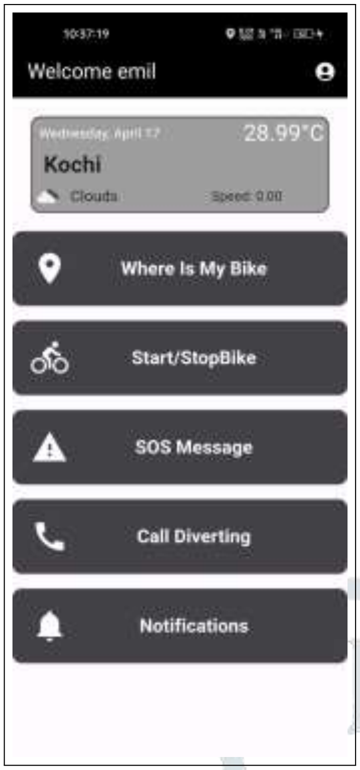

Fig. 4. App Home Screen

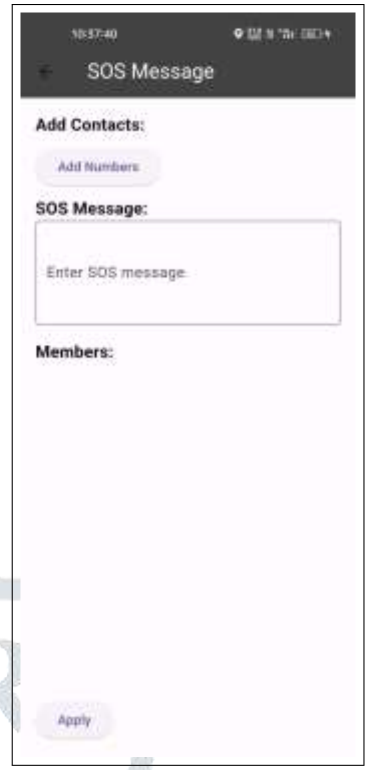

Fig. 5. SOS contact window

communication between ESP8266 and ESP32 devices without the need for an intermediary access point (AP) or router. ESP-NOW operates in a low-power mode, making it suitable for battery-operated devices and applications requiring efficient wireless communication. Devices in an ESP-NOW network are categorized into two roles: ”Initiator” and ”Responder.” Initiators send data packets to Responder devices, and Responders can send responses back to Initiators if required. ESP-NOW uses MAC addresses to address devices and establish communication links.

2) MQ-3 Sensor: The MQ-3 alcohol sensor, engineered by Winsen Electronics, operates by utilizing a sensitive semiconductor gas sensor paired with a heating element. When exposed to alcohol vapor, the sensor’s resistance changes, enabling it to detect alcohol concentrations accurately. This mechanism makes it a vital tool in applications such as breathalyzers and industrial safety systems, where precise alcohol detection is essential for maintaining safety standards and regulatory compliance.

3) NEO-6M: The NEO-6M GPS module operates by receiving signals from multiple satellites orbiting Earth. Using these signals, it calculates its position, velocity, and precise time. The module’s built-in receiver processes the incoming signals and extracts the necessary information to determine its location. This data is then made available to the host device, typically through a serial communication interface like UART. By continuously updating its position based on satellite signals, the NEO-6M provides real-time location data to applications, enabling accurate navigation, tracking, and timing functionalities.

Fig. 6. MQ3 Sensor

4) SIM800L: The SIM800L module operates by interfacing with a SIM card and connecting to the GSM cellular network. It communicates with the host microcontroller or device through UART (Universal Asynchronous Receiver-Transmitter) communication protocol. Once powered on and connected to the network, the module can perform various functions such as making and receiving voice calls, sending and receiving SMS messages, and establishing data connections for transmitting and receiving data over the internet. Its

Fig. 7. NEO-6M

integrated TCP/IP stack enables it to handle communication protocols for data transfer.

Fig. 8. SIM800l

5) SPI: SPI (Serial Peripheral Interface) is a synchronous serial communication protocol used to connect microcontrollers with peripheral devices. It operates through four main signal lines: Serial Clock (SCLK), Master Out Slave In (MOSI), Master In Slave Out (MISO), and Slave Select/Chip Select (SS/CS). The master device generates a clock signal (SCLK) to synchronize data transmission, while data is sent from the master to the slave (MOSI) and from the slave to the master (MISO). The SS/CS line selects the specific slave device with which communication occurs. SPI operates in full duplex mode, allowing simultaneous data transmission in both directions.

6) Relay: A relay is an electromechanical device used to control the flow of electricity in a circuit. It consists of a coil, typically made of copper wire, which generates a magnetic field when an electric current passes through it. This magnetic field then attracts or repels a switch, called the armature, which is connected to one or more sets of contacts. When the coil is energized, the contacts either close or open, depending on the relay's configuration, allowing or interrupting the flow of current in the controlled circuit.

Fig. 9. 5V relay

7) ADXL345: The ADXL345 is a highly advanced and versatile digital accelerometer sensor developed by Analog Devices. Operating on the principle of micro-electromechanical systems (MEMS), it accurately measures acceleration forces in three perpendicular axes: X, Y, and Z. The sensor employs small, movable components suspended in a silicon substrate, which generate electrical signals proportional to the applied acceleration. These signals are then processed by the sensor's onboard analog-to-digital converters (ADCs) and made available to the host microcontroller through standard digital communication interfaces such as I2C or SPI

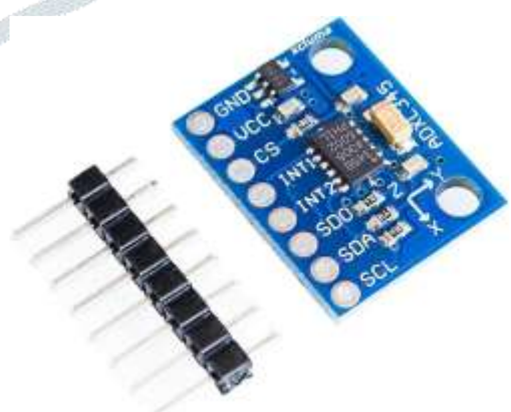

Fig. 10. ADXL345

8) ESP32: The ESP32, a formidable microcontroller developed by Espressif Systems, epitomizes versatility and efficiency within the domain of embedded systems. Representing a significant advancement over its predecessor, the ESP8266, the ESP32 seamlessly integrates dual-core processors, Wi-Fi connectivity, Bluetooth capabilities, and a comprehensive array of peripheral interfaces, rendering it an exemplary solution for an expansive spectrum of Internet of Things (IoT) applications. Its dual-core architecture facilitates concurrent task execution, thereby bolstering multitasking proficiency, while its judicious power management mechanisms ensure prolonged battery life in battery-operated devices. It is supported by a robust community and an abundance of development resources.

Fig. 11. Esp32

IV. Results and Discussions

Statistical concepts such as weighted mean was used to analyze the data. After finishing the hardware and software development of the system, it was subjected to testing to assess the functionality and performance of the implemented system. Data collected were based on main six functionalities provided in the system

TABLE I
Rated functionality of the system

Rated Functionality of the System		
Descriptive Rating (EF)	Weighted Mean	Rating Scale
Exceedingly Functional (EF)	4.21-5.00	5
Very Functional (VF)	3.41-4.20	4
Functional (F)	2.61-3.40	3
Somewhat Functional (SF)	1.81-2.60	2
Not Functional (NF)	1-1.80	1

The participants for the test were chosen in a random manner. The no of participants chosen for the test were 20. Table 2 shows the result on functionality side of the smart helmet system. Participants chose six core functions of the system which were alcohol detection, lock detection, location tracking, fall detection, sms control and mobile app performance. The participants were given to rate performance of each functionality on a scale of 0 to 5. Alcohol detection got an average rating of 4.7, lock detection got 4.6, location tracking got 4.65, fall detection made 4.6 and sms control got 4.8. The mobile app received an average rating of 4.6 .The core functionalities together averaged 4.67. The average score can be considered a good score out of 5.

TABLE II
Assessment of the Functionality of Smart Helmet

Indicators	Weighted Mean	Description
Alcohol detection	4.7	Exceedingly Functional
lock detection	4.6	Exceedingly Functional
location tracking	4.65	Exceedingly Functional
fall detection	4.6	Exceedingly Functional
SMS controls	4.8	Exceedingly Functional
Mobile app performance	4.6	Exceedingly Functional
General Mean	4.66	Exceedingly Functional

By adopting a quantitative study, the performance and relevance of the suggested system was evaluated. By collecting relevant data from participants the core features were rated and data showed that the system was performing well. A positive feedback was obtained from the participants of the test regarding the performance of the proposed system.

V. Conclusions and Recommendations

Motorcycle safety and convenience are two areas where Helmassist is a trailblazer in the ever changing world of technology. Our initiative revolves around a cutting-edge hardware piece that, when combined with our intuitive mobile application, signals the beginning of a new age in riding experiences. Helmassist's purpose is to empower users by combining cutting-edge technology with a strong dedication to human empowerment. Our gadget prioritises safety and convenience without sacrificing the exhilaration of the ride, providing an extensive array of functions that have been painstakingly designed to enhance the riding experience. Through Helmassist, we genuinely believe that riders of all backgrounds should have more equitable access to safer and more intelligent riding techniques. Our project's motivation is not just to create a product but also to take a bold approach to influencing motorcycle safety in the future. Helmassist goes beyond the typical bounds of motorcycle accessories by giving riders direct control over increased safety and convenience. Every line of code, features incorporated into our hardware, and people impacted by our mobile application—all of these things—have a lasting impact on the motorcycle safety landscape because of Helmassist's unwavering commitment to creating a future where riding is not only thrilling but also essentially safer and smarter. The features that can be added later would be being powered by solar, implementing a cooling system, and also a virtual hud for displaying information.

In future iterations of our smart helmet project, we aim to introduce several exciting features to enhance user experience and safety. One key aspect will be the implementation of a virtual dashboard, providing real-time data and metrics to the wearer. Additionally, we plan to integrate collision possibility detection and warning systems, utilizing sensors to alert users of potential dangers. Another enhancement will be an information relaying system within the helmet, enabling users to receive and send messages seamlessly. Voice assistance through Google will also be incorporated, allowing for hands-free operation and interaction. Finally, we aim to introduce a swipe-enabled interface, making it easier for users to navigate through the helmet's features and settings. These additions will not only improve the functionality of our smart helmet but also enhance its usability and safety features.

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