AI-IoT based smart helmet with Frequency based vehicle control

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Abstract

This paper presents an AI – IoT based smart helmet system with machine learning enhancements aimed at improving motorbike safety. The helmet integrates the LeNet Convolutional Neural Network (CNN) to monitor rider fatigue by analyzing facial features in real-time, issuing alerts when signs of drowsiness, such as frequent blinking, are detected. The system also includes a vibration sensor to detect accidents and initiate emergency protocols, as well as a blind spot detection system using ultrasonic sensors to monitor a 180-degree area for potential collisions. Communication between the helmet and vehicle is facilitated by Zigbee technology, ensuring reliable real-time data exchange. This integrated solution addresses critical safety issues such as driver fatigue, accident detection, and blind spot awareness, offering a comprehensive approach to enhance rider safety.

Keywords: Smart helmet, IoT, machine learning, LeNet CNN, driver fatigue detection, accident detection, vibration sensor, ultrasonic sensor, blind spot detection

I. INTRODUCTION

This study presents a smart helmet system designed to augment road safety through an integrated approach. The system interfaces seamlessly with an ARDUINO UNO microcontroller, utilizing a multifaceted module affixed to the helmet. This module incorporates a push button to check if the In addition to drowsiness monitoring, the smart helmet incorporates sensors designed to enhance spatial awareness. Blind spot sensors, strategically placed to detect vehicles or obstacles in the driver's peripheral areas, emit alerts that help the driver stay informed of potential hazards otherwise hidden from view. This blind spot detection system fosters safer lane changes and maneuvers, especially in high-traffic areas where visibility is limited. The helmet is also equipped with a vibration sensor for accident detection. Concurrently, a GPS module pinpoints the accident location and transmits it to emergency responders, allowing for precise location tracking and faster intervention. The driver is wearing the helmet and uses Lenet CNN architecture to detect driver's fatigue levels.[1].

Leveraging the LeNet convolutional neural network (CNN) architecture, the system accurately detects driver drowsiness, issuing timely alerts to prevent accidents. Additionally, sensors strategically placed to detect blind spots behind the driver provide real-time alerts, promoting heightened awareness and reducing collision risks. Accident detection is achieved through a vibration sensor, prompting the GSM module to dispatch an alert message. Simultaneously, the GPS module transmits the accident's precise location. To mitigate obstacles, an ultrasonic sensor is deployed, automatically halting the vehicle upon obstacle identification. The ultrasonic sensor is augmented with a servo motor for efficient monitoring through rotation.[2].

This comprehensive smart helmet system offers a holistic approach to road safety, encompassing aspects such as proper helmet usage, prevention of drowsy driving, real-time accident reporting, and obstacle avoidance. The integration of multiple sensors and communication modules contributes to a robust and effective solution for minimizing road accidents and enhancing overall driving safety

II. LITERATURE REVIEW

[1] Mahesh S Gour (Dept of ECE), Druva Kumar S (Dept of ECE), Pradeep Kumara (Dept of VLSI design), Majuthana S (Dept of VLSI design) proposed an smart helmet system is designed for enhanced road safety, integrating various modules with the primary Arduino processor. Two modules, one on the helmet and the other on the bike, utilize RF transmitters and receivers for synchronization. When the helmet is worn, encrypted data is transmitted to the bike module, enabling the ignition only when validation conditions, like helmet usage, are met. An alcohol detection sensor serves as a breathalyzer, preventing bike ignition if alcohol is detected. In the event of an impact, a vibration sensor triggers GSM and GPS modules, sending an SMS with GPS coordinates to the registered number and activating a buzzer for attention. The helmet includes a microphone and speaker for emergency communication. This comprehensive system addresses helmet usage, alcohol detection, distracted driving prevention, real-time accident reporting, and obstacle avoidance through sensor integration and communication modules.

[2] Pranav Pathak from the Electrical Engineering department has proposed a system that consists of two main

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components: the Helmet Unit and the Motorbike Unit (MU), which communicate with each other using RF technology and the NRF24L01 module. The Helmet Unit is equipped with several sensors embedded in an Arduino Nano, including a pulse rate sensor to monitor the rider's heart rate. Once the helmet is worn and the buckle is locked, the NRF module is activated, establishing a connection with the Motorbike Unit. The pulse rate information is continuously sent to the MU. The MU is equipped with a LIDAR sensor, which can detect vehicles behind the bike and alert the rider to approaching vehicles for increased safety awareness. Additionally, sensors on the handle grip and middle of the bike are able to detect the position of the rider's hands and legs. The system can warn the rider if they are getting into a dangerous riding position. Separate accelerometers on both units allow for independent accident detection for both the rider and the bike. The Helmet Unit, powered by an Arduino Nano with ATmega328, is lightweight thanks to the small size of the board and sensors. The helmet includes a pulse rate sensor and an MQ-3 alcohol sensor on the front. The Motorbike Unit, which utilizes an Arduino Mega with ATmega2560, receives sensor data from the Helmet Unit via the NRF module. It is equipped with various sensors, such as a hall effect sensor for bike speed, ultrasonic and infrared sensors for hand and leg position detection, GSM and GPS modules for communication with the rider's location, an OLED screen for displaying messages, a buzzer for rider alerts, a LIDAR sensor for detecting approaching vehicles, a push- button switch for rider safety, a relay for ignition control, and an accelerometer for measuring bike tilt and detecting accidents.

[3] Jesudoss A, Vyabhavi R and Anusha B proposed a smart helmet integrates multiple sensors, including an IR sensor, load sensor, vibration sensor, gas sensor for alcohol detection, and MEMS technology for handlebar control. It aims to enhance safety by monitoring parameters such as vehicle load, potential accidents through vibrations, and detecting alcohol consumption. The system requires users to create accounts with the server, storing essential details for user access control. Load monitoring utilizes a load cell, issuing alerts if the load surpasses a specified limit. Alcohol detection relies on a gas sensor near the helmet's mouth area, issuing warnings for drunk driving. The microcontroller serves as the system's core, facilitating communication with the server and ensuring an automated safety system for vehicles. Accident detection involves a vibration sensor identifying sudden impacts, triggering alerts to the police. The system continuously monitors accelerometer output and external impact sensors, taking appropriate measures in case of severe accidents, including notifying hospitals.

[4] Huma Afreen, jhuita Nandi, Rohit Kundu, Ankit Dutta in their project serves multiple critical objectives aimed at enhancing rider safety. Firstly, the system promotes responsible riding habits by ensuring the motor starts only when the rider wears the helmet and activates the switch. This mechanism encourages compliance with essential safety practices. Additionally, the project incorporates an alcohol content testing feature using an MQ-3 sensor. While programmed for demonstration purposes, the system sets a threshold limit of MQ-3 sensor. While programmed for demonstration purposes, the system sets a threshold limit of 0.04 mg/L, below the limit for driving under the influence. If the alcohol content exceeds this limit, the system prevents the rider from operating the motorcycle, addressing a key safety concern. Furthermore, the system integrates a vibration sensor for accident detection. By identifying frequencies generated during accidents or encounters with obstacles, the system can promptly alert the rider to potential hazards. In the unfortunate event of an accident, the project facilitates effective emergency response by continuously sending latitude and longitude coordinates to pre-registered SIM numbers via the GSM module. This real-time location tracking ensures swift assistance and improves overall safety measures on the road. In essence, the smart helmet project adopts a holistic approach to rider safety, addressing issues of helmet usage, alcohol consumption, accident detection, and location tracking.

[5] J Joy Mathavan, V K D Wijesekara, N Satheeskanth, W M U J Wanasinghe,M Maathushan,V V Wijenayake (Department of Engineering Technology, Faculty of Technology, Kilinochchi Premises, Ariviyal Nagar, University of Jaffna, Sri Lanka) in introduces an smart helmet that is designed to start the motorbike and prevent accidents through three distinct modes: Start ON mode, Running Mode, and Accident mode. These modes utilize various sensors and have been tested in real-time environments. It aims to enhance motorcycle safety through three modes: Start ON, Running, and Accident. In the Start ON mode, the helmet's controller checks if it's worn properly, the side stand is up, and there's no alcohol consumption before activating the engine. The Running mode utilizes a gyroscopic sensor to monitor the bike's inclination, automatically stopping the engine if the bike tilts beyond a set angle, potentially signaling an accident. The Accident mode is triggered in case of a significant tilt, sending an "accident detected" message to a pre-registered phone number. The system allows users to customize settings and update emergency contacts based on their location. The successfully tested model includes a display screen integrated into the motorcycle's dashboard for more information and emergency messages. This comprehensive system ensures engine activation conditions, monitors bike inclination to prevent accidents, and facilitates timely communication in case of emergencies.

[6] Guntupalli Sireesha,Anusha,K. Baby Satya Jahnavi,Ayusha Baburay(Computer science dept) in introduces an system that achieves three main objectives: monitoring the status of the rider wearing a helmet, detecting alcohol content, and detecting and sharing the location of accidents. In the helmet section, a transmitter is placed in the helmet, and a receiver is installed on the bike, enabling wireless communication between the two modules. When the rider wears the helmet, a switch is pressed, and an alcohol sensor in the helmet detects alcoholic gas from the rider's breath. If the alcohol sensor indicates an excessive alcohol level, the bike's ignition is turned off. The helmet also contains an accelerometer to measure helmet tilting, and the microcontroller embedded in the helmet processes the data. The output is transmitted to the bike module through an RF transmitter. To start the bike ignition, two conditions must be met: the rider must wear the helmet, as confirmed by the switch in the helmet, and the rider's alcohol consumption should not exceed a threshold value. The bike's ignition will only start when both conditions are satisfied. The accelerometer in the helmet monitors the helmet's tilt concerning the ground, and if it exceeds the threshold value, indicating an accident, the system immediately notifies a registered contact number using GSM. Additionally, it sends the location of the accident, allowing for prompt assistance and medical treatment.

[7] Mohammad Ehsanul Alim (School of Electrical & Electronic Engineering), Sarosh Ahmad (Department of Electrical Engineering),Marzieh Naghdi Dorabati(Faculty of Computer Engineering),Ihab Hassoun(Faculty of Engineering) in the paper presents a Smart Helmet design using IoT [16] , incorporating Arduino Mega-2560 for the bike unit and Arduino Nano for the helmet unit. The helmet features a sharp IR sensor for detecting helmet usage and an MQ-3 sensor for alcohol detection. The nRF24L01 RF module enables communication between the helmet and bike units, with an OLED display issuing warnings for drunk driving and non- helmet usage. Testing reveals that the bike only starts when the user is sober and wearing a helmet. The system integrates a GSM-GPS module for accident detection and location tracking. In case of an accident, the GPS module identifies the location, displayed on Google Maps, and sends a text message to the rider's family for prompt assistance. The comprehensive system aims to enhance rider safety by preventing drunk driving, ensuring helmet usage, and facilitating quick response in case of accidents.

[8] Dr.S.Sekar, L.Jaivenkatesh, S.AravindKumar, DineshKumar, N.Jeevanantham (AssistantProfessor (Sel.G), Department of IT, Student, Department of Information Technology) proposed motorcycle safety system targets helmet non-usage, drunk driving, and delayed accident response. It consists of a Helmet Unit and a Bike Unit, employing specialized sensors and modules. An Infrared sensor in the helmet ensures proper usage, blocking ignition if worn incorrectly. A MQ-3 gas sensor detects alcohol levels, stopping ignition if alcohol is present. Radio Frequency communication connects the Helmet Unit as a transmitter and the Bike Unit as a receiver. The Bike Unit, with Arduino MEGA, Ultrasonic Sensors, GSM SIM800L, and GPS Neo 6m, verifies helmet usage and checks for alcohol. Ultrasonic sensors address blind spots, alerting the rider to approaching vehicles. In accidents, the GPS module identifies the location, and GSM sends swift SMS notifications to emergency contacts. The system integrates advanced sensors and communication for enhanced motorcycle safety and rapid accident response.

[9] Mohamed A. Torad, Mustafa Abdul Salam proposed an smart helmet system integrates hardware and software components, utilizing Android, Firebase, and Arduino tools for its implementation. The system integrates accident detection and real-time tracking using a Piezoelectric Sensor to capture various environmental changes. An Android mobile app connects to the helmet through Firebase Realtime Database, serving as a central hub for data storage and management. Firebase's low-latency synchronization is leveraged for efficient real-time updates, making it a suitable solution. The tracking system utilizes GPS and Arduino to facilitate location sharing, emergency notifications, and tracking features. The mobile app, featuring two Java classes (PhoneAuthActivity and MapsActivity), ensures user privacy through authentication methods. An "Add friends" function streamlines permission for tracking, emphasizing privacy and mutual consent. The system's efficiency lies in the detailed algorithms for phone authentication and data retrieval from the database.

[10] P Koteswara Rao, P Tarun Sai, N Vinay Kumar, SK Yusuf Vidya Sagar introduced a smart helmet concept prioritizes rider safety by checking for helmet usage and sobriety. If both conditions are met, the ignition is allowed; otherwise, it remains off, with an LCD display indicating the status. The system incorporates a mercury switch for accident detection, triggering GPS and GSM messages to notify a designated contact person with exact coordinates. IoT integration involves storing rider data, including helmet condition, alcohol status, and accidents, on ThingSpeak. An 8-bit AVR microcontroller manages system functions, utilizing a relay module for ignition control. IoT cloud services enhance data management, offering scalability, while a DC power supply converts AC to various voltages for system components.

III. METHODOLOGY

The development process of the smart helmet system initiates with setting up the necessary hardware components. This system seamlessly communicates with an ARDUINO UNO microcontroller, which serves as the central processing unit of the setup. Affixed securely to the helmet is a versatile module that contains a variety of sensors and components essential for the system to function properly. These components include a push button, LeNet CNN architecture, vibration sensor, ultrasonic sensor, and servo motor. A key focus of the system is on ensuring correct helmet usage and detecting driver fatigue. To accomplish this, a push button sensor is used to confirm if the driver is wearing the helmet correctly, an important step in enforcing safety protocols. Furthermore, the system uses the LeNet CNN [14] architecture to continuously monitor the driver's tiredness levels by analyzing facial expressions and eye movements in real-time. This allows the system to issue timely alerts when signs of drowsiness are detected, helping to prevent potential accidents. Another crucial aspect addressed by the smart helmet system is the identification of blind spots and the prevention of crashes. Sensors strategically placed behind the driver to detect blind spots provide instant alerts, significantly improving the driver's awareness of their surroundings and reducing the risk of collisions, particularly when other vehicles are nearby. Accident detection and reporting mechanisms are essential components of the system's operation. A vibration sensor is employed to quickly detect accidents, triggering the GSM module to send an alert message to predefined contacts upon detection of an accident. At the same time, the GPS module transmits the exact location of the accident, facilitating fast emergency response and aid. The system also includes an obstacle avoidance mechanism to further enhance safety. An ultrasonic sensor is used to identify obstacles obstructing the vehicle's path, and when an obstacle is detected, the system automatically stops the vehicle to prevent potential collisions. The functionality of the ultrasonic sensor is enhanced by a servo motor, which allows for efficient monitoring through rotation and improves the accuracy of obstacle detection. By integrating these components and features, the smart helmet system offers a holistic approach to road safety by addressing key areas like proper helmet usage, fatigue prevention, real- time accident reporting, and obstacle avoidance, ultimately enhancing overall driving safety[1].

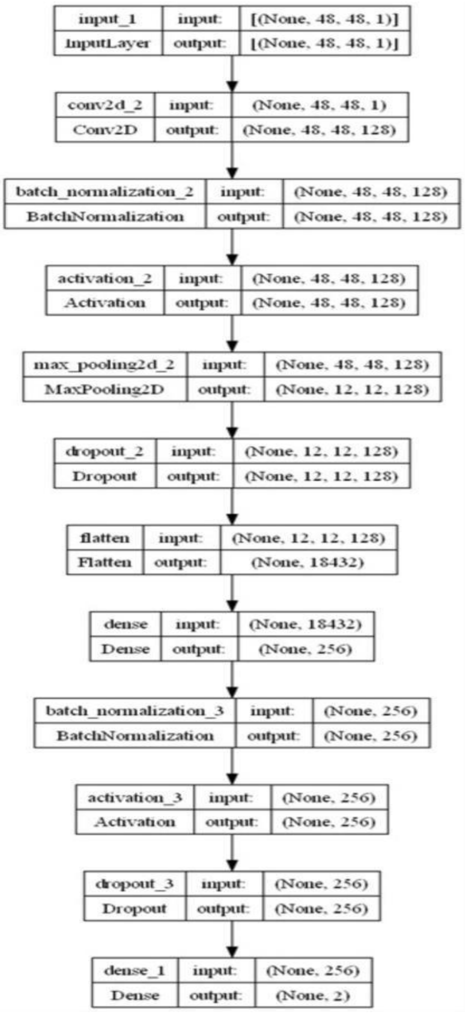

Fig.1. Architecute of Lenet – CNN

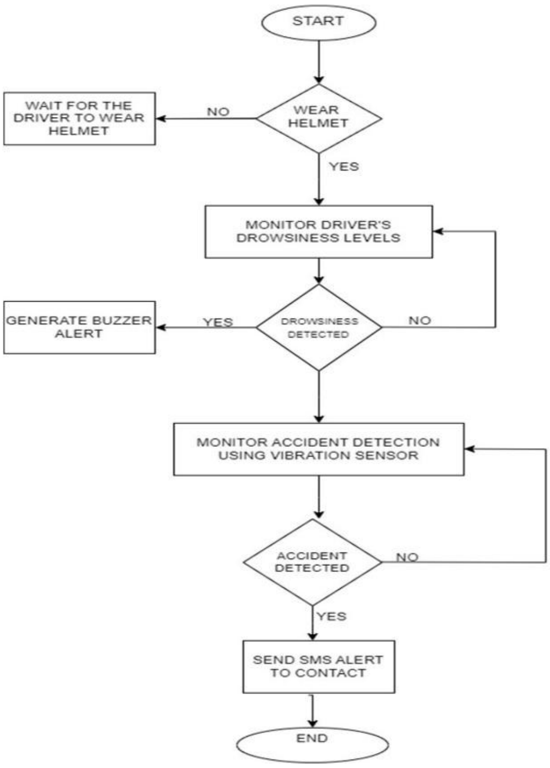

Fig.2. Flow chart for drowsiness detection systems

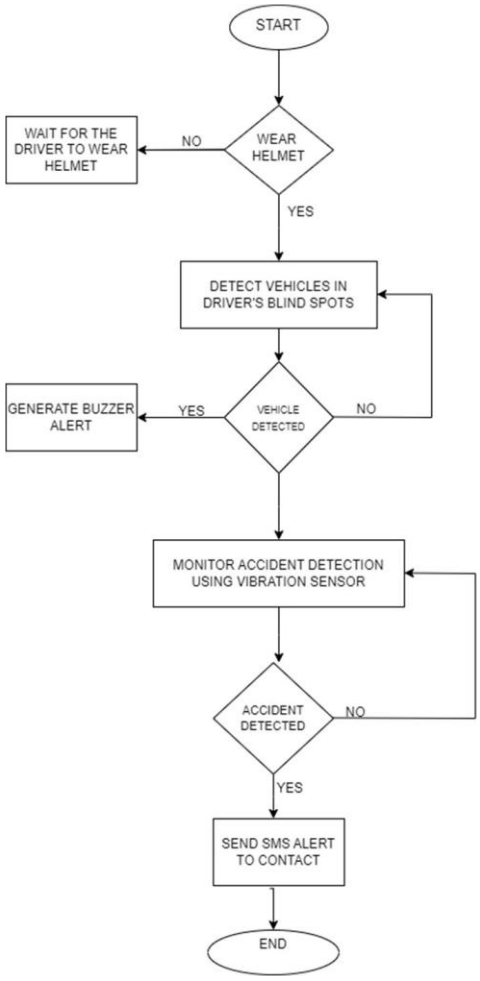

Fig.3. Flow chart for Blind spot detection systems.

IV. PRINCIPLE OF OPERATION

The advanced smart helmet system utilizes a combination of sensors and technologies, controlled by an ARDUINO UNO microcontroller, to greatly improve road safety. The system is centered around a push button sensor that is built into the helmet, ensuring that the helmet is worn correctly by requiring the driver to confirm its secure placement on their head manually. This confirmation activates the safety features of the helmet and is necessary before the vehicle can be started, enforcing crucial safety precautions right from the start. To monitor the driver's level of alertness, the system utilizes the LeNet Convolutional Neural Network (CNN), which examines live video footage of the driver's face for signs of fatigue like yawning, frequent blinking, or drooping eyelids. If these signs are detected, alerts are issued, such as activating a buzzer in the helmet, to remind the driver to take a break, preventing potential accidents caused by drowsiness. In addition, the system incorporates blind spot and ultrasonic sensors to enhance the driver's awareness of the surroundings. [15] The blind spot sensors detect vehicles that are not visible in the rearview mirrors and alert the driver visually or audibly to risky maneuvers. At the same time, the ultrasonic sensors check for obstacles near the vehicle, such as pedestrians, other vehicles, or unexpected debris, offering timely warnings to avoid frontal collisions. The effectiveness of these sensors is improved by a servo motor that rotates them to extend their range and enhance environmental monitoring accuracy. In case of an accident, a vibration sensor detects unusual forces on the vehicle and immediately triggers the system's emergency response procedures. The GSM module is activated to send automated SMS alerts to predetermined emergency contacts, including first responders and family members, notifying them of the incident. Simultaneously, the GPS module transmits precise geographic data about the accident location, aiding in swift and accurate emergency services deployment. This thorough incorporation of proactive safety measures and rapid emergency response capabilities establishes the smart helmet system as a robust solution for increasing road safety, encouraging safer driving practices, and ensuring prompt assistance during critical situations.

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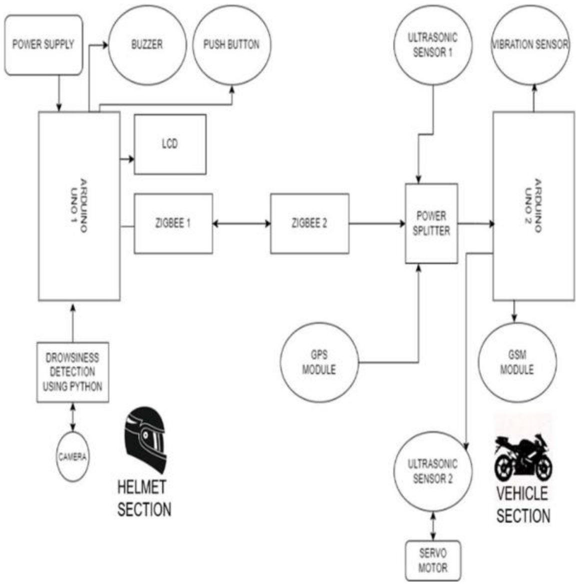

Fig. 4 Helmet Architecture

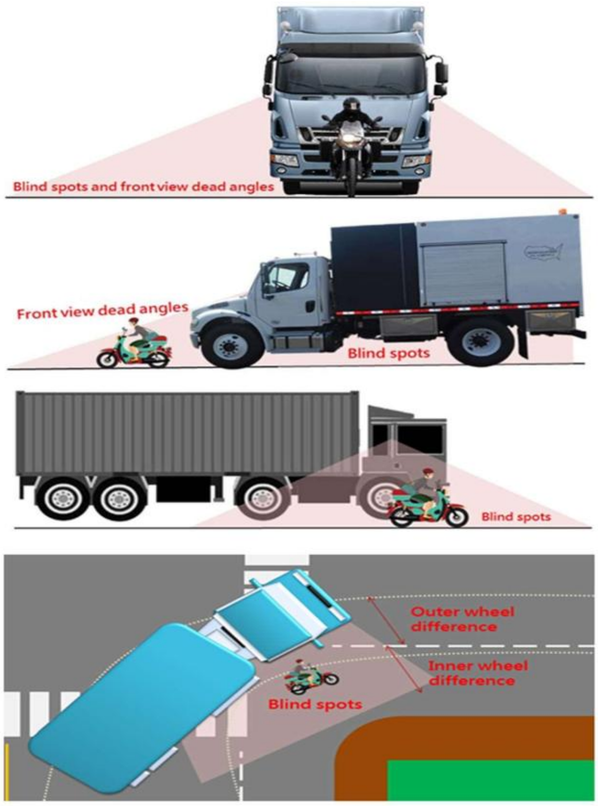

Fig.5.Blind spots and Obstacle avoidance

V. TESTING & RESULTS

The evaluation of the smart helmet system went through a detailed and phased testing process. It commenced with thorough individual testing of each component including the push button, LeNet CNN, blind spot sensors, ultrasonic sensors, servo motor, vibration sensor, GSM module, and GPS module to ensure they operated correctly in isolation. Once the individual tests were successful, integrated system testing was carried out to evaluate the seamless interaction between the microcontroller and sensors in simulated driving scenarios. This involved assessing the system's responsiveness to incorrect helmet positioning, drowsiness, obstacles, and blind spots. Real-world scenario simulations were conducted with volunteers in controlled environments to assess the system's performance under practical conditions, such as driving while fatigued, changing lanes, reacting to sudden obstacles, and mock accident situations to test accident detection and emergency response protocols. Feedback was constantly gathered from test drivers and system operators to improve sensor sensitivity, system ergonomics, and alert mechanisms. The results from these extensive tests were positive: the push button sensor accurately detected proper helmet use over 98% of the time, the LeNet CNN[14]. identified signs of fatigue with approximately 95% accuracy, blind spot sensors detected vehicles correctly over 90% of the time, and the vibration sensors consistently triggered emergency protocols in all simulated accidents, with the GSM module sending alerts quickly and the GPS module accurately pinpointing accident locations. These results confirm that the smart helmet system has the potential to significantly improve road safety by ensuring compliance with safety standards, detecting hazards early, and facilitating efficient emergency communication

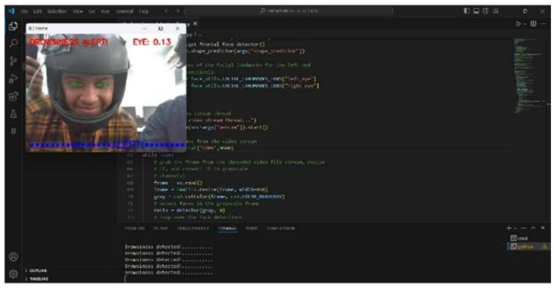

Fig.5 Drowsiness Detection using LeNet CNN

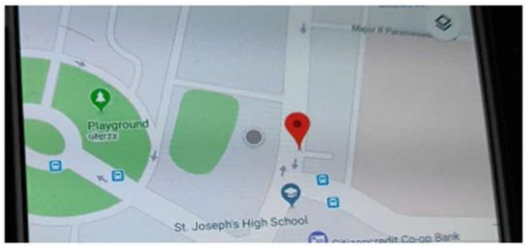

Fig.6. Google map location sent by the motorbike unit

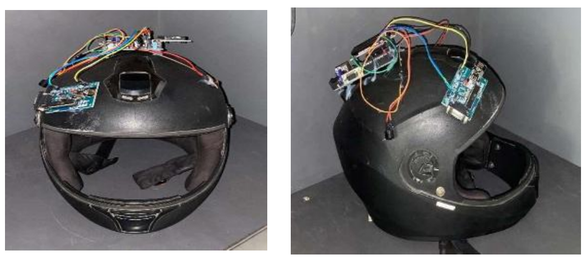

Fig.7. Output of the Helmet section

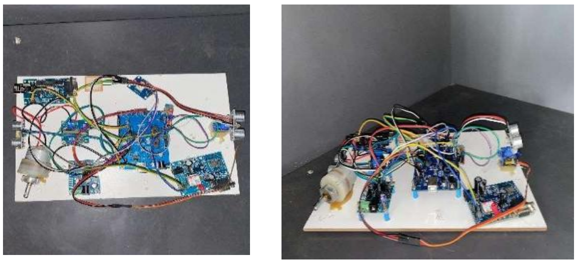

Fig.8 Output of the Vehicle section

VI. CONCLUSION

Extensive testing and robust outcomes of the smart helmet system clearly show its significant potential in enhancing road safety. The system integrates advanced technologies like the LeNet convolutional neural network (CNN) to detect driver drowsiness, strategically placed blind spot sensors, and ultrasonic sensors for comprehensive obstacle detection. It also includes an efficient emergency response mechanism using vibration sensors, GSM, and GPS modules for quick and accurate communication in case of an accident. The system's high reliability in detecting proper helmet usage, monitoring signs of fatigue accurately, and alerting drivers to potential road hazards highlights its sophistication and effectiveness. The thorough testing has indicated that the smart helmet system has a promising ability to enhance road safety. It makes use of advanced technologies such as the LeNet convolutional neural network (CNN) [16] for identifying driver drowsiness, strategically positioned blind spot sensors, and ultrasonic sensors for obstacle recognition. It also consists of an efficient emergency response mechanism incorporating vibration sensors, GSM, and GPS[10] modules for rapid and precise communication during accidents. Its high accuracy in detecting correct helmet usage, monitoring signs of fatigue meticulously, and cautioning drivers about potential dangers showcases its effectiveness and sophistication. Moreover, its capability to quickly send emergency alerts and provide accurate location information to first responders highlights its potential to save lives in crucial situations. The smart helmet system is not only a technological advancement but also a significant step forward in automotive safety, promoting safer driving practices and enhancing overall safety by addressing risks proactively and ensuring swift accident responses. The success of this initiative emphasizes the benefits of incorporating advanced safety systems across different driving scenarios and vehicle types, paving the way for further improvements and broader adoption with the aim of making roads safer and reducing traffic-related fatalities on a larger scale. The positive results from this venture underscore the necessity of ongoing investment and research to extend these technologies to a broader audience and address new road safety challenges.

VII. FUTURE WORK

The intelligent helmet design has the potential to be enhanced by incorporating extra components to enable the project. A range of bioelectric sensors could be integrated to keep track of various motorcycle aspects, including the battery level, tire pressure, and fuel in the main tank. Implementing a small camera on the motorcycle or helmet could monitor the activities of the rider and even dictate which routes they are permitted to take. [15] It is possible to install sensors to enable motorcycles to communicate important information about traffic congestion, accidents, and general communication to other motorcycles. Furthermore, integrating solar power into the helmet could also function as a means to charge the user's mobile phone. In terms of security measures, multiple sensors like a temperature sensor can be added, along with alcohol detection tools such as MQ-2 sensors. The use of a Mic sensor could also detect if the user is engaged in a phone conversation. These potential developments represent the future directions for the project.

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