Smart Traffic Surveillance System for Detecting Helmetless Riders Using IOT and ESP32-Cam

D.MAHALAKSHMI[1], E. MANOHAR GOWD[2], B.NANDINI[3], B.AMRUTHA[4],K.SAINATH REDDY[5], P.DILSHAD[6],P.VYSHNAVI[7]

[1,2,3,4,5,6,7,]STUDENTS

Ms.M.JHANSI

Assistant Professor, Dept.of ECE

Department of Electronics and Communication Engineering,
Sri Venkateswara Institute of Technology, Anantapur-515722, Andhra Pradesh, India.

---***---

Abstract - The use of helmets for riding motorbikes is critical and vital as it helps prevent life-threatening injuries if an accident occurs. Helmet detection is a significant yet challenging vision task in traffic monitoring and accidents avoidance for bike riders. With the increase in bike accidents in several nations due to the lack of power to impose traffic laws and mostly the negligence of the bike rider. The proposed method aims to detect no helmet bikers and extract the license number plate so that they can be issued a fine. This article highlights an automatic helmet detection method, which incorporates, Feature descriptor and DNN-classifier. The system is trained on predefined datasets and uses the DNN (Deep Neural Networks) classifier to classify the detected vehicles, as described in the proposed method works as follows, Preprocessing, Feature extraction and Classification. This article proposed a method that will classify whether or not the person riding the bike is wearing a helmet. In terms of robustness and efficiency, this proposed method achieves high accuracy detection rates.

Keywords-ESP32-CAM,ESP32-Microcontroller,Helmat detection, Ignition control.

1. INTRODUCTION

Recently, road safety has become an important public issue, especially in the countries where 2 wheelers are one of the most popular means of transport. One of the main causes of the high rate of road accidents is the lack of protective gear—especially helmets. Although there are strict traffic laws and educational campaigns on road safety, the reality is that many motorcyclists and their passengers do not wear helmets and will incur life-threatening head injuries on impact.The traditional way to enforce helmet rules is a manual approach of having traffic authorities check for helmets, as well as face-observation through CCTV. However, manual approaches are time consuming, labour intensive, and impractical to implement 24 hours a day in urban and rural environments. Manual private surveillance systems can also lead to inadvertent non-observations or inadvertent errors made by a person leading to ineffective enforcement.This opens the opportunity in possibility of real time illegal helmet observance by deploying an automated helmet violation detection that is effective in real time which assists traffic safety enforcement. With advancements of the Internet of Things (IoT) and low-cost embedded systems, we have the ability to innovate through technology that have the ability to solve traffic reporting and observation issues. In terms of the automated helmet violation detection, we could employ the ESP32-CAM module, and affordably, and smaller IoT device to in essence make viewing-error free decisions regarding observation. The ESP32-CAM

module has a recognizable camera and AI frequency processing to capture events and catalogue these events to report incidents.

2. LITERATURE SURVEY

[1] Helmet Detection System Utilizing Machine Learning, the Authors are R. Kumar, P. Sharma, and A. Verma, in this research proposed a helmet detection system using image processing and deep learning processes, and they implemented a Convolutional Neural Network (CNN) to classify images of helmet-wearers and non-helmet-wearers. The model achieved a high degree of accuracy in lab-controlled settings, but there were challenges in natural environments with shifting lighting and angles of images. The authors reiterated the important

of lightweight models for future real-world applications in traffic monitoring.

[2] Real-Time Helmet Detection Utilizing YOLO and OpenCV, Authors are S. Patel, D. Mehta, and K. Reddy, this research proposed an automated helmet detecting system utilizing YOLO (You Only Look Once) and OpenCV. The authors trained YOLO on a dataset of motorcycle riders, and the system was able to perform detecting in real-time. The system was able to collect the violation of the camera feeds, ultimately removing the requirement for the manual checking of traffic camera feeds. The limitations cited were false positive detection and the computational resources required to optimize the product performance.

[3] Smart Traffic Management Using IoT and AI, L. Fernandez, M. Gupta, and T. Bose looked at the fusion of IoT and AI to manage smart traffic, including helmet detection. The authors used the Raspberry Pi with a camera module in this research for real-time processing of video images. The authors recommended using IoT-based surveillance for law enforcement, and noted challenges included network dependability and hardware limitations. The authors added that there would be scalability with cloud processing.

[4] Low-Cost Helmet Detection System Using ESP32-CAM, J. Singh, H. Roy, and A. Das produced their own low-cost helmet detection using ESP32-CAM, which they did due to its inbuilt camera and Wi-Fi streaming capability. The researchers did local edge processing to analyze images and reduce reliance on processing via the cloud. Although the system was low-cost, they mentioned ESP32-CAM struggled with complex backgrounds and required proper brightness for accurateness of detection. The authors added their dream for an affordable solution to act as a traffic monitoring system with the ESP32-CAM.

[5] AI-Based Traffic Rule Violation Detection, Authors were M. Iqbal, K. Nair, and S. Thakur, the study focused on the use of AI for traffic rule enforcement (e.g., helmet detection; red light violations; speed violations), using computer vision and deep learning the system would detect violations occurring in real time traffic footage and automatically log an offender ticket. The study was effective, however, the model required significant computational resources which would not allow it to be implemented on low power devices, such as the ESP32-CAM. The study suggested AI models be optimized for edge computing.

[6] Switch-Based Safety System for Two-Wheelers, The authors were P. Rao, N. Kulkarni, and V. Sharma. This study described a switch-based helmet detection system, in which the motorcycle engine would start only in the event that the rider wore a helmet. The system would use a either cavity mounted RFID or button push switch used to detect if the rider had worn the helmet. The system would leave the ignition disabled if the switch had not engaged thereby not potentially allowing the vehicle to start. While this system was rated highly effective for helmet usage enforcement, the current implementation required a modification to the vehicle, and could potentially be bypassed using fake or additional switching implementation.

3. PROPOSED METHODOLOGY

Our proposed system seeks to improve road safety by determining if a motorbike rider is wearing a helmet or not using an IoT device based on the ESP32-CAM. This approach involves setting up the ESP32-CAM to be the central part of the system, as it has a camera and Wi-Fi capability. The ESP32-CAM takes pictures of the rider in real-time as they ride, which can display whether they are wearing a helmet or not. The ESP32-CAM runs a small machine learning model that has been trained to determine if the rider is or isn't wearing a helmet. This machine learning model will initially have been trained on a labeled dataset of images of motorcycle riders, so that it could differentiate riders that were wearing a helmet from riders that weren't. The training then concluded with the model being compressed (for example, TensorFlow Lite) to deploy on the ESP32-CAM as an embedded device. Once deployed, the ESP32-CAM will take pictures and conduct inference locally and will send an alert over Wi-Fi to an IoT platform like Firebase or Blynk if the rider is not wearing a helmet. The alert can be an indication to, for example, send a notice to a mobile app, secure a database for the violation, or in more advanced mechanisms, inhibit bike ignition.

3.1 Block Diagram

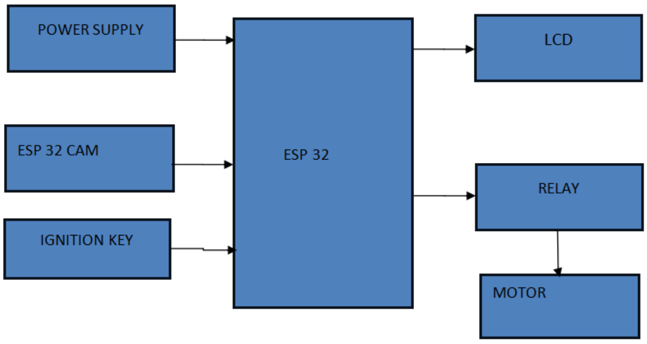

Figure 1: Block Diagram

a.ESP32 Microcontroller:

The ESP32 is a compact, powerful micro-controller from Espressif Systems, and is known for its short range wireless capabilities using built-in Wi-Fi and Bluetooth. Additionally, the ESP32 is easy to program, via a dual core processor, multiple GPIO pins, and multiple interfaces, such as SPI, I2C, UART, and ADC. The ESP32 is a good option for applications like IoT, smart devices, and automation projects, as it is fast, energy efficient, and works well with the Arduino platform, and also MicroPython.

b.ESP32-CAM Module:The ESP32-CAM is a small microcontroller module that combines an OV2640 camera withan ESP32-S chip, enabling real-time capturing and processing imagas. The module is used for capturing images of the bike rider and sending the images for the next processing step of the system, which uses AI-based model object detection. The module also has W-Fi and Bluetooth to transmit data to cloud platforms for remote monitoring; and is able to also use a microSD card for storing images locally for future analysis.

c.Ignition Key: The ignition key is a crucial part of rider safety. Unlike traditional motorbikes that directly power the engine with the ignition key turned, this system uses the ignition key along with a smart helmet detection process. The ESP32-CAM first checks if the rider has donned the helmet using image processing. The engine then starts, only after detecting the helmet, by triggering a relay to complete the ignition circuit. The ignition key now is simply a conditional switch where the logic for conditional operation is driven by helmet detection logic to prevent the rider from riding unsafely.

d.Relay: Relay modules also contain small circuit switches (relays) with support components such as LEDs and transistors. Each relay acts as an electrically controlled switch that is powered by an electromagnet, and both AC and DC loads can be applied to that relay as long as it is used within the relays rated power.

3.2 System Architecture & Working Principle:

The newly developed system aims to improve rider safety by ensuring that the motorcycle cannot start unless a helmet is worn. The system architecture simply consists of a power supply, an ignition key, an ESP32-CAM module, an ESP32 microcontroller, an LCD, a relay module, and a motor, which represents the bike's engine. When the ignition key is turned on, the power supply stimulates the ESP32-CAM module, which initializes and immediately takes an image of the rider on the bike. After the image is taken, the ESP32 microcontroller processes the image by analyzing the image to determine if the rider was wearing a helmet by using a data-driven pre-trained model.

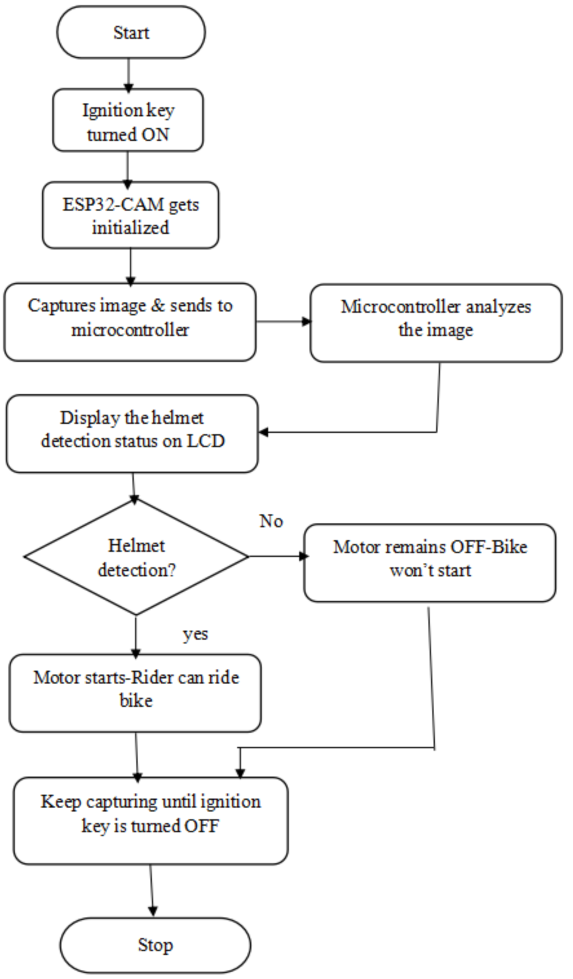

Figure 2: Flow Chart of Working of proposed system

After the analysis, the system proceeds to the next steps based on the results of the analysis. If the helmet is

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 04 | April - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

detected, the system will communicate with the LCD by producing a message that states "Helmet Detected" while simultaneously activating the relay module. The relay module receives its signal and opens the channel for current to flow from the power supply to the motor, which then starts the engine and allows the rider to move to the next destination. When the microcontroller determines that the rider is not wearing a helmet, it instantly triggers a signal to the LCD which displays the message: "No Helmet Detected." At the same time, the relay intervenes and cuts off the current to the motor. This means that the engine will not start and the bike will remain off. This allows the rider cannot operate the bike until they have a helmet on.As a simple yet effective way to promote helmet use and reduce serious head injury should an accident occur, this is important. The advantage of the system is that it operates in real-time and does not require any manual verification. This relieves some responsibility from traffic enforcements, while reinforcing safer riding through the automatic verification of whether or not a helmet is being worn.

3.3 Hardware Implementation

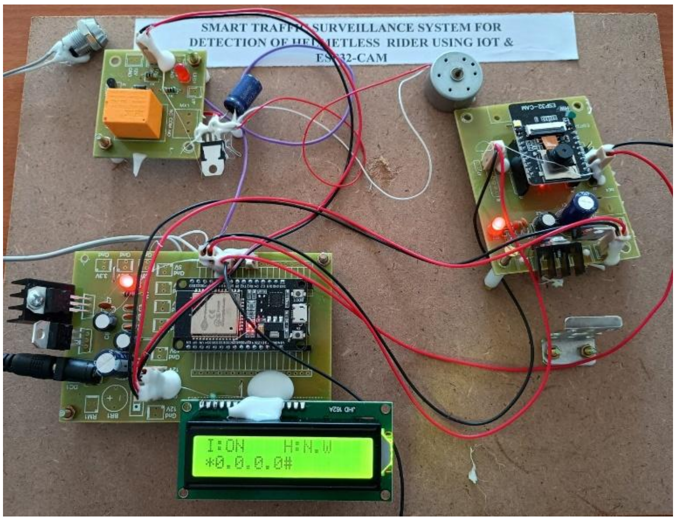

Figure 3: Physical Connecion of System

4. RESULTS : Since we found that this system monitors bike riders in real-time and detects whether they are wearing a helmet or not.According to the detection result ,the system allows or blocks the starting of motor.

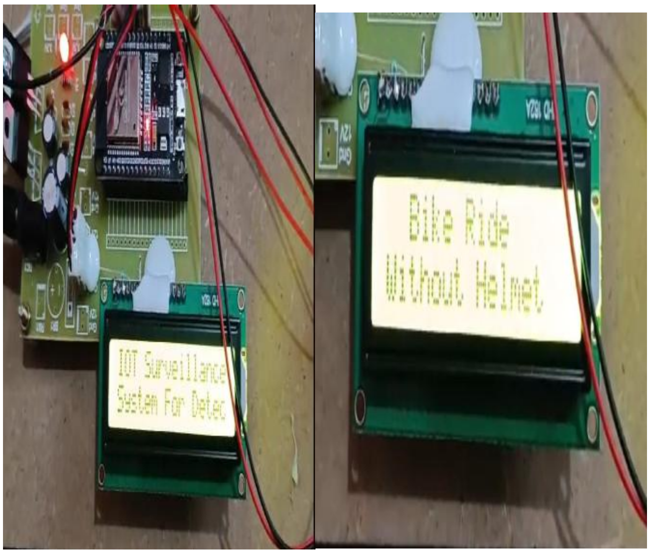

Figure 4.1: Initializing IOT Surveillance System for detection of bike ride without helmet

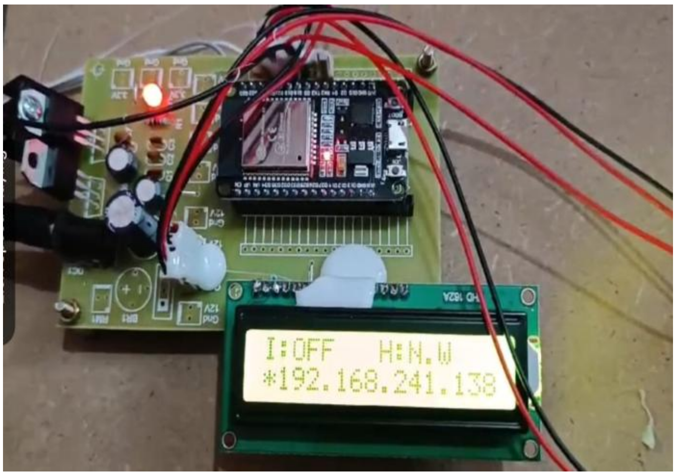

Figure 4.2:Indicating Ignition is OFF

Figure 4.3: Indicating Ignition is ON

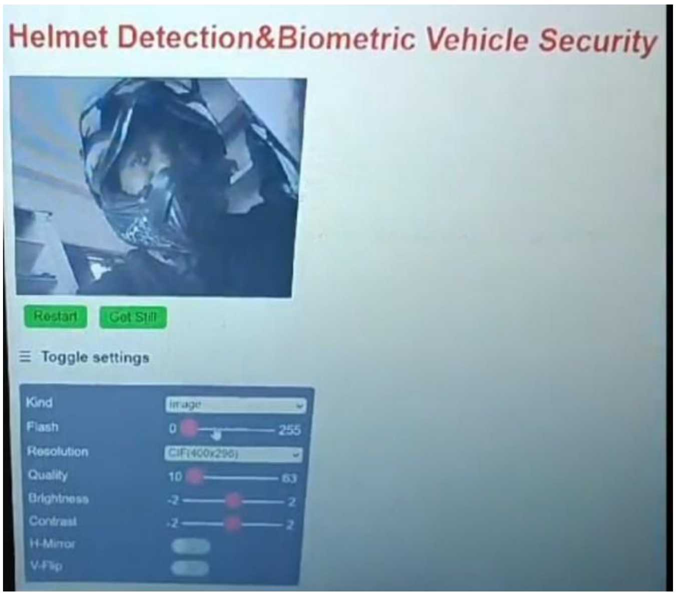

Figure 4.4:Image Captured by ESP32-CAM,rider with helmet

5. CONCLUSION

In this paper the helmet-based bike ignition system successfully ensures rider safety by allowing a motorcycle to only start if a helmet is detected on the rider's head. The system uses the ESP32-CAM module, a microcontroller, an LCD display, and a relay to capture and process real-time pictures of the rider's head in to detect helmet usage. When a helmet is detected, the relay is activated allowing the motor to start; when a helmet is not detected, the motor will not start. The system is intended to encourage responsible riding and curtail preventable accidents that occur through rider negligence in wearing a helmet. The system is relatively cheap, automated, and easy to utilize for two-wheeled vehicles. It decreases a subordinate's involvement in monitoring and enforces safety standards in real-time. In summary, the project provides an effective and practical measure toward improved roadway safety, and has great potential for implementation in urban and rural settings.

6. FUTURE SCOPE

In the future, this system can be improved to become even smarter with more reliable helmet detection in additional good and bad lighting or weather conditions. We can also look at a way to add triple riding detection to make the system even better at encouraging safer rides on the road. To enhance the user environment, there is the possibility of linking the system to a mobile app or cloud data storage to keep track of rider violations. With a few touches, this same teacher app could be programmed directly onto real bikes so that safer riding is a reason to ride and could reduce accidents on the road.

7. REFERENCES

[1] R. Kumar, P. Sharma, and A. Verma, “A Neural Network Framework for Helmet Detection in Video,” Journal of Human-centric Computing and Information Sciences, vol. 11, May 2020.

[2] S. Patel, D. Mehta, and K. Reddy, “Helmet Detection in Real-Time with YOLO and Open-CV,” International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE), vol. 9, no. 7, July 2021.

[3] L. Fernandez, M. Gupta, and T. Bose, “Intelligent Traffic Monitoring Using IoT and AI,” Proceedings of the 10th IEEE International Conference on Smart Technologies, 2020.

[4] J. Singh, H. Roy, and A. Das, "Low-Cost, Real-Time Helmet Detection System Using ESP32-CAM," International Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), vol. 10, no. 04, April 2022.

[5] M. Iqbal, K. Nair, and S. Thakur, “Traffic Rule Violation Detection System Using AI,” International Research Journal of Engineering and Technology (IRJET), vol. 8, no. 11, November 2021.[6] P. Rao, N. Kulkarni, and V. Sharma, “Switch-Based Safety System for Two-Wheelers,” Journal, vol. 7, JETIR, no. 5, May 2020.

[6] P. Rao, N. Kulkarni, and V. Sharma, "Switch-Based Safety System for Two-Wheelers", International Journal of Emerging Technologies and Innovative Research (JETIR), vol. 7, no. 5, pp. 456–460, May 2020.

[7] R. K. Yadav, A. Bhargava, and S. Malik, "Smart Helmet-Based Ignition System Using IoT", International Journal of Scientific Research in Computer Science, Engineering and Information Technology (IJSRCSEIT), vol. 6, no. 1, pp. 101–105, Jan. 2020.

[8] S. N. Gupta and P. B. Dhage, "Helmet Violation Detection Using Deep Learning Techniques", IEEE International Conference on Communication and Signal Processing (ICCSP), pp. 1004–1008, 2021.