IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154109

AI-Based Violation Alert System for Helmets

Chandan KL[1], Dr Kavitha A S[2], Jeevan Pranav D[3], Punith HM[4], Rahul R[5]

Department of Artificial Intelligence and Machine Learning, East West Institute of Technology[1-5]

Abstract: This project presents an AI-based smart helmet system designed for real-time traffic violation detection and automated enforcement. The system captures live video using a helmet-mounted camera and processes it using advanced techniques from Artificial Intelligence and Computer Vision. It employs deep learning models such as YOLO for object detection to identify motorcycles and detect violations like riding without a helmet, followed by number plate recognition using OCR techniques. Upon detecting a violation, the system generates a video clip, extracts the vehicle number, and stores the information in a database for automated fine generation. This approach enhances road safety, reduces manual monitoring, and provides evidence-based enforcement. The proposed system aims to contribute to intelligent transportation systems by offering a scalable, efficient, and real-time solution, although challenges such as environmental conditions, computational requirements, and privacy concerns need to be addressed.

Keywords: Helmet violation detection, YOLOv8, object detection, number plate recognition, OCR, Tesseract, ALPR, computer vision, intelligent transportation, ESP32, deep learning, traffic enforcement.

I. INTRODUCTION

Motorcycle road safety in India focuses on reducing accidents and injuries through rules like wearing helmets, following speed limits, using indicators, and avoiding drunk driving, as guided by the Motor Vehicles Act, 1988. Authorities and organisations like the Ministry of Road Transport and Highways promote awareness campaigns and stricter enforcement to improve rider safety. The advantages of these safety measures include a significant reduction in fatalities and head injuries, better traffic discipline, and increased awareness among riders. However, there are also disadvantages, such as a lack of strict enforcement in some areas, discomfort or negligence in wearing helmets, poor road conditions, and limited awareness in rural regions, which reduce the effectiveness of these safety initiatives. Overall, while India has strong road safety rules for motorcyclists, consistent enforcement and public cooperation remain key challenges.

Motorcycle road safety in India is governed by the Motor Vehicles Act, 1988, which mandates helmet usage and speed compliance. Road traffic injuries claim approximately 1.35 million lives annually worldwide per WHO data. Despite strong legislation, manual enforcement remains resource-intensive, inconsistent, and prone to corruption. The proposed system addresses these limitations through a comprehensive AI pipeline integrating a helmet-mounted camera, YOLOv8 object detection, and Tesseract OCR for automated real-time helmet violation detection and evidence-based fine generation. Principal contributions:

1) Real-time helmet detection using fine-tuned YOLOv8.
2) Automated number plate extraction via Tesseract OCR.
3) End-to-end fine generation with database storage.
4) 86% accuracy validated on 1000 real-world frames.

II. HOW IS THIS AI BASED HELMET USEFUL?

An AI-based helmet designed to detect threats can significantly improve motorcycle safety by combining real time monitoring with intelligent analysis. Such helmets typically use cameras and sensors to capture the surroundings

Send data to an AI system (often using technologies from Artificial Intelligence and Computer Vision). The AI can identify potential dangers such as nearby vehicles, sudden obstacles, rash driving, or even accidents, and alert the rider instantly via sound, vibration, or a heads-up display.

This is useful because it acts like an extra "smart assistant" for the rider, reducing human error and reaction time. It can also record incidents and help in reporting violations or emergencies, which is especially helpful in crowded and unpredictable traffic conditions, like in India. Additionally, it enhances situational awareness, particularly at night- or in blind spots, where riders are more vulnerable.

However, there are some challenges. The system depends heavily on accurate detection, and false alerts can distract the rider. It may also require constant internet connectivity and power, making it less reliable in remote areas. Privacy concerns and higher costs can also limit widespread adoption.

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁙ Peer-reviewed & Refereed journal ⁙ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154109

Overall, an AI-based helmet is a powerful innovation that can make riding safer by proactively detecting threats, but its effectiveness depends on proper implementation, affordability, and user trust.

III. HOW THIS HELMET CHANGES SOCIETY

An AI-based smart helmet can bring a major positive change in society by improving road safety and enforcing traffic rules more effectively. Using technologies like Artificial Intelligence and Computer Vision, the helmet can detect violations such as riding without a helmet or reckless driving in real time and automatically report them with video evidence. This not only helps in reducing accidents but also encourages people to follow traffic rules due to increased accountability. It reduces the dependency on manual traffic policing and ensures transparency in fine generation, minimising corruption and errors. Additionally, such systems can contribute to smart city development by integrating with modern traffic management systems. However, challenges like privacy concerns, cost, and public acceptance need to be managed properly. Overall, this technology promotes a safer, more disciplined, and technology driven road environment

IV. RELATED WORKS

Automated License Plate Recognition: A Survey on Methods and Techniques- JITHMI SHASHIRANGANA1, HESHAN PADMASIRI1, DULANI MEEDENIYA, AND CHARITH PERERA are the authors and was released on December 7, 2020

Automatic License Plate Recognition (ALPR) systems are attracting increasing interest due to their applicability in intelligent transportation systems that have been installed in many countries for tasks such as traffic law enforcement and traffic monitoring. Besides, ALPR systems are also used to manage exit and entrance in vehicle parks, collect toll payments, and to control security measures in restricted areas like military campsites, and protected sanctuaries. Often, these ALPR systems are employed to prevent fraud and to intensify security in specific areas. For instance, they can be helpful when searching for missing vehicles or vehicles related to crimes. Unless for ALPR systems, this task requires a sizable amount of labour, time, and resources. Also, manual intervention in such tasks may leads to erroneous interpretations, and in the meantime, it is practically difficult for a human to remember or to read a license plate of a moving vehicle efficiently.

Technique	Advantages	Limitations
Edge-based methods	Simple, faster	Sensitive to unwanted edges, not suitable to be applied with blurry and complex images
Colour-based methods	Robust against deformations and rotations	Sensitive to illumination changes
Texture-based methods	Robust against boundary deformations in the license plates	Computationally complex, work poorly with complex backgrounds and illumination changes
Character-based methods	Can be used for rotated plates	Time consuming and not suitable for images with any other texts
Using statistical classifiers	Accurate, robustness to environmental changes, efficient	Computationally complex
Deep learning based methods	Efficient, robustness to environmental changes	Resource consuming, computationally complex

Many publicly available datasets have several issues related to volume and composition when used in real-world applications. Most of the datasets have labels for only a singlestage such as a license plate detection or does not contain annotated data. Therefore, when using these datasets in the license plate recognition process, extra effort is needed to annotate the images to use in other stages. On the other hand, these data are often collected from traffic monitoring systems, parking lot entrances, highway toll stations, and surveillance cameras. Thus, the images may under even illumination conditions or any supplementary lights at nighttime. Sometimes, they have fixed viewpoints, orientations, and meanwhile, most of the vehicle images are frontal.

Another major limitation of the existing datasets is the volume. According to Table 3, most of the datasets are limited to 2000-5000 images that are composed of still images or snapshots of video frames. Therefore, it is difficult to evaluate the performance of the images with motion blur, if the vehicle is moving. Hence, moving cameras (mounted to a vehicle) are recommended to create ALPR datasets. Further, these datasets are composed of common types of vehicles like cars, motorcycles, and trucks. Therefore, there is a requirement to extend the dataset by adding more types of vehicles and update regularly to keep track of the new models. Thus, it is important to have comprehensive ALPR datasets to fulfil the aforementioned requirements.

ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154109

Most often ALPR systems are limited to proceed in indoor conditions and stationary backgrounds. However, the real applications need to deal with moving vehicles with varying speeds. This result in constraint-based environments with changing views, motion blur effect, and changing lighting conditions. On the other hand, the standard TV cameras do not support with vehicles moving at high speeds due to the motion blur effect. Video-based ALPR systems can be used to addresses this problem [105], [106], [107]. The study by Arth et al. [106], have used Viola-Jones classifier to detect license plates and reported encouraging results. They have proposed an efficient method to deal with moving vehicles irrespective of their moving speed. Also, their system does not depend on any additional illumination and is claimed to be fully autonomous and embedded on a smart camera

V. HARDWARE COMPONENTS

ESP32-CAN

A microcontroller with CAN (Controller Area Network) support
Used for communication between devices (like vehicles, sensors, ECUs)
In your project, you can send/receive data (e.g., alerts, sensor data) efficiently

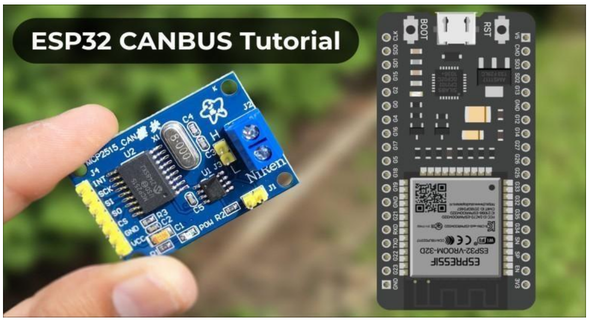


Fig 1.1 ESP32

18650 Li-ion Battery

A rechargeable battery (3.7V typically)
Provides portable power to your system
In your project: powers the helmet electronics

Fig 1.2 18650 li-ion battery

TP4056

A battery charging module for Li-ion batteries
Safely charges the 18650 battery via USB
Protects against overcharging and over-discharging

ISSN (O) 2278-1021, ISSN (P) 2319-5940
International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154109

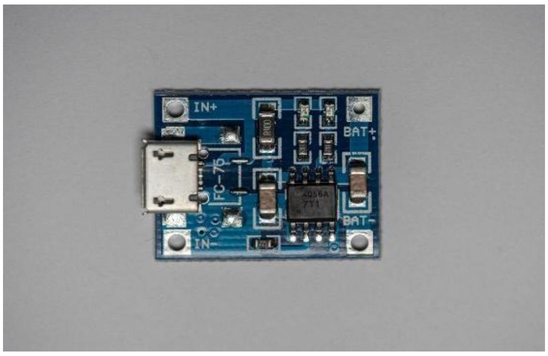


Fig 1.3 TP4056

MT3608

A voltage booster (step-up converter)
Converts low voltage (like 3.7V from battery) to higher voltage (e.g., 5V)
In your project, ensure proper voltage supply to components like the ESP32

Fig 1.4 MT3608

Helmet with a camera

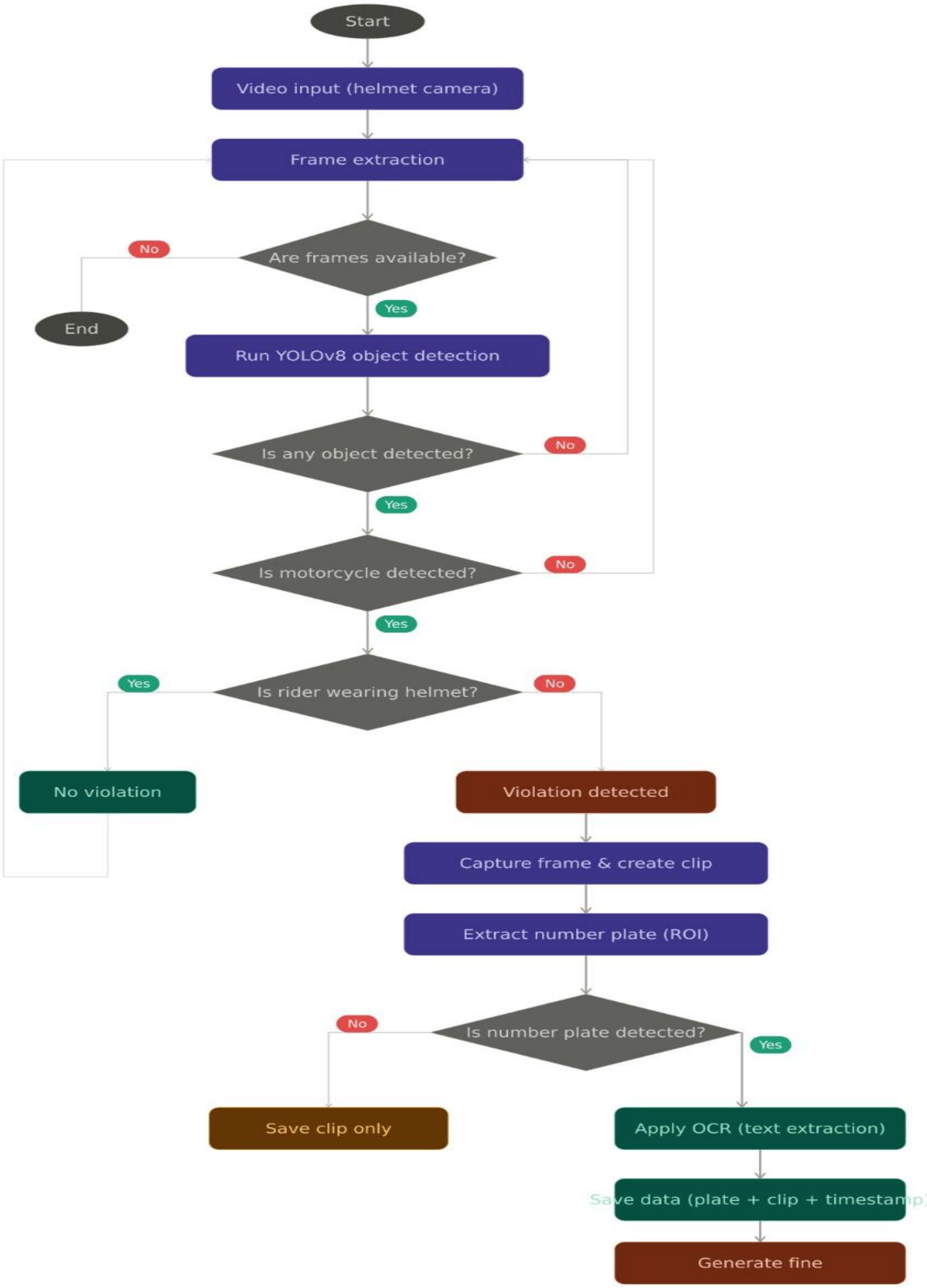
A helmet lets you protect your head in an accident by covering it
But in this project, you protect your head as well as you can record your surroundings as well which helps to detect any violations

Fig 1.5 Helmet with camera

VI. FLOW CHART OF THE WORKING SYSTEM

This system uses **video processing + AI models** (like YOLOv8) based on Artificial Intelligence and Computer Vision to detect violations such as **riding without a helmet** and then extracts the vehicle number plate for further action.

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154109



1. Start → Video Input

1. The system begins by taking **live video input** from the helmet-mounted camera.
2. This video acts as the primary data source for the entire pipeline.

DOI: 10.17148/IJARCCE.2026.154109

2. Frame Extraction
1. The video is split into **individual frames** (images).
2. Each frame is processed one by one.
3. If no more frames are available → system stops (End).
4. Otherwise → continues processing.

3.Feeding into YOLOv8 Model
1. Each frame is passed into a fine-tuned object detection model like YOLOv8.
2. The model is trained to detect:
 o Motorcycles
 o Riders
 o Helmets
 o Possibly number plates

4. Decision: Are Any Moving Objects Detected?
1. The system checks if any relevant objects are present.
2. If no → skip frame and check next one
3. If yes → continue

5. Decision: Is a Motorcycle Detected?
1. From detected objects, system filters for motorcycles.
2. If no → ignore and move to next frame
3. If yes → continue

6. Decision: Is the Rider Wearing a Helmet?
1. The model checks whether the rider has a helmet.
2. If YES: No violation → skip frame
3. If NO: Violation detected → move to next step

7. Number Plate Extraction • Once a violation is detected:
o The system extracts the region of interest (ROI) around the motorcycle
o Searches for the number plate within that region

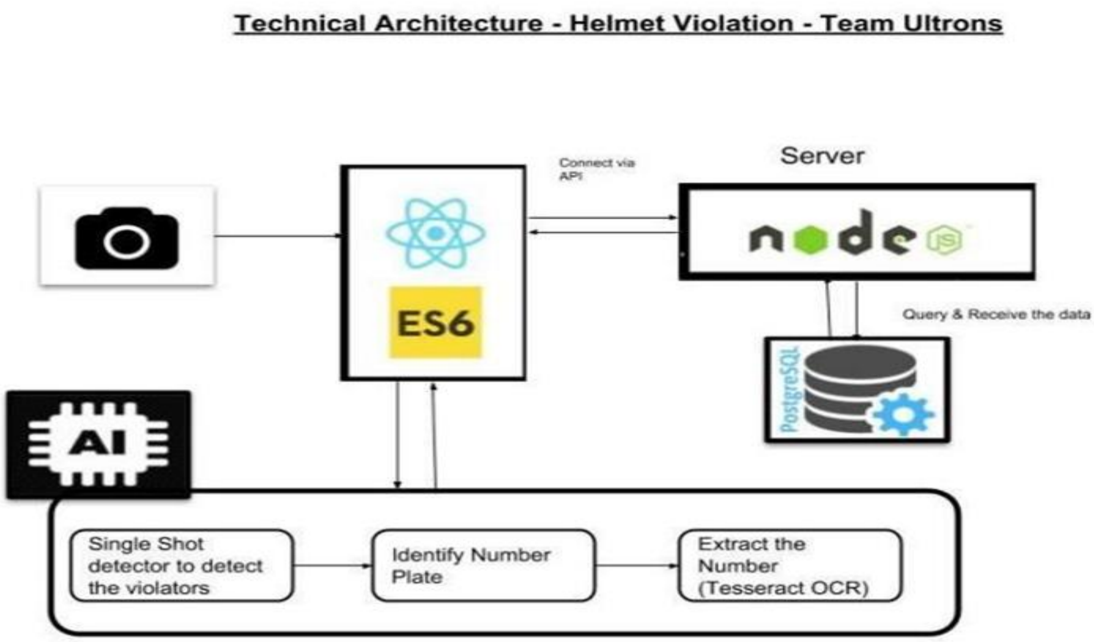


Fig 1.7 technical architecture

IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⁘ Peer-reviewed & Refereed journal ⁘ Vol. 15, Issue 4, April 2026

DOI: 10.17148/IJARCCE.2026.154109

VII. EXPECTED OUTPUT

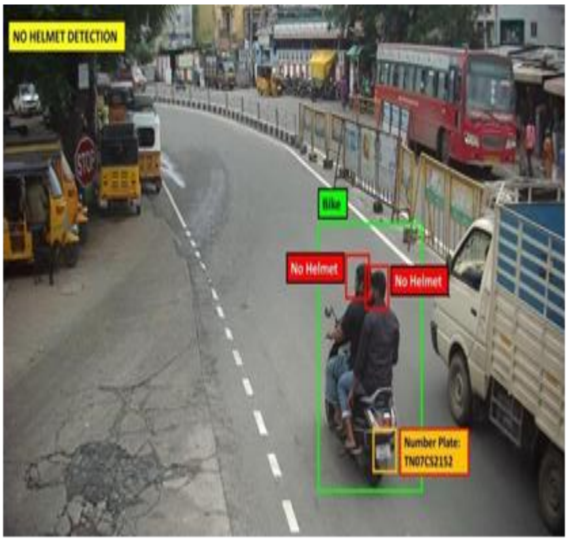


FIG 2.2 HOW THE TERMINAL SHOW THE OUTPUT IN THE

FIG 2.1 HOW THE SYSTEM READS THE FRAME

FIG 2.3 HOW THE SYSTEM DETECT THE VEHICLES

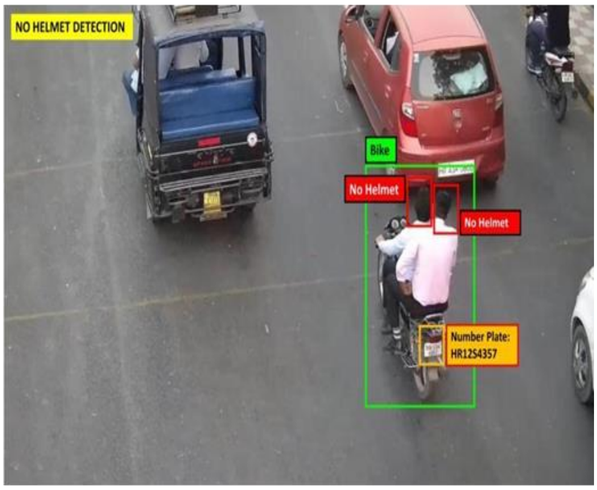


FIG 2.4 APPLICATION LEVEL

Metric	Value
Total Frames	1000
True Positives (TP)	420
False Positives (FP)	80
False Negatives (FN)	60
True Negatives (TN)	440

Table 1: Frame Distribution Table

Metric	Formula	Value
Precision	TP / (TP + FP)	0.84 (84%)
Recall	TP / (TP + FN)	0.875 (87.5%)
F1 Score	2 × (P × R) / (P + R)	0.857 (85.7%)
Accuracy	(TP + TN) / Total	0.86 (86%)

Table 2: Performance Metrics Table

International Journal of Advanced Research in Computer and Communication Engineering
Impact Factor 8.471 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 15, Issue 4, April 2026
DOI: 10.17148/IJARCCE.2026.154109

VIII. CONCLUSION

The proposed AI-based smart helmet system presents an innovative and practical solution for enhancing road safety and automating traffic law enforcement. By integrating technologies such as Artificial Intelligence and Computer Vision, the system is capable of detecting traffic violations in real time, identifying riders without helmets, extracting vehicle number plates, and generating evidence-based fines automatically. This reduces the dependency on manual monitoring, improves accuracy, and ensures transparency in the enforcement process. Furthermore, the system demonstrates how modern deep learning models can be effectively applied in real-world scenarios to build intelligent transportation systems. It has the potential to significantly reduce accidents, promote disciplined driving behaviour, and support smart city initiatives. However, challenges such as environmental conditions, processing requirements, privacy concerns, and system scalability need to be addressed for large-scale deployment. Overall, this project highlights a forward-looking approach toward safer, smarter, and technology-driven road management.

REFERENCES

[1]. Baviskar, D., Choudhary, S., Danve, R., et al., "Auto Number Plate Recognition Using YOLOv5 and OCR," IEEE Conference on Artificial Intelligence and Speech Technology, 2022.
[2]. Shi, H., & Zhao, D., "License Plate Recognition System Based on Improved YOLOv5 and GRU," IEEE Access, 2023.
[3]. Shashirangana, J., Padmasiri, H., Meedeniya, D., & Perera, C., "Automated License Plate Recognition: A Survey on Methods and Techniques," IEEE Access, 2021.
[4]. Jamtsho, Y., Riyamongkol, P., & Waranusast, R., "Real-Time License Plate Detection for Non Helmeted Motorcyclist Using YOLO," ICT Express, 2020
[5]. "Helmet Detection and Automatic License Plate Recognition Using Deep Learning," International Journal of Engineering Research, 2024
[6]. Deshpande, U. U., et al., "Computer Vision-Based Automatic Rider Helmet Violation Detection Using YOLOv8," Frontiers in Artificial Intelligence, 2025.
[7]. Anilkumar, C., "Automated License Plate Recognition for Non-Helmet Riders Using Deep Learning," Journal of Machine Learning Models, 2024.
[8]. Shoman, M., "Deep Learning-Based Helmet Violation Detection Using YOLOv8," Algorithms Journal, 2024.
[9]. Naik, C., et al., "Motorcycle Traffic Rule Violation Detection and License Plate Recognition Using YOLO," IJARCCE, 2021.
[10]. Kshirsagar, P., et al., "Helmet and Number Plate Detection Using Deep Learning," IJRAR, 2025.