International Journal of Science Engineering and Advance Technology, IJSEAT, Vol. 14, Issue 2, S1 | ISSN 2321-6905 2026

YOLOV8-BASED HELMET AND PLATE DETECTION WITH BILINGUAL OUTPUT

T.Jyothi[1,*] D.Soumya[2] B .Harishwar Reddy[2] B . Prasanth[2] Ch .Abhilash[2]
[1]Assistant Professor, Department of CSE(DS), TKR College of Engineering, Meerpet, Telangana 500097
[2]B.Tech (Scholar), TKR College of Engineering, Meerpet, Telangana 500097
*Correspondence: jyothi.t@tkrcet.com

ABSTRACT
Road accidents and traffic violations, particularly the non-usage of helmets and unregistered vehicles, remain a serious concern in developing nations. Manual monitoring by traffic police is often inefficient and error-prone. To address this challenge, we propose an Automatic Helmet and License Plate Detection System with Bilingual Output using YOLOv8. The system integrates real-time helmet detection and license plate recognition with bilingual (English and regional language) feedback, ensuring wider accessibility and usability. Leveraging YOLOv8's advanced object detection capabilities, the model achieves high accuracy and real-time performance.. Experimental results demonstrate that our approach achieves an mAP of over 90% for helmet detection and license plate recognition, with an average inference speed of 35 FPS on GPU. The proposed system can be deployed for intelligent traffic monitoring, law enforcement, and smart city applications.

Keywords: Helmet Detection, License Plate Recognition, YOLOv8, Bilingual Output, Road Safety, Deep Learning, Computer Vision.

1.INTRODUCTION

Road safety is a major concern worldwide, especially in densely populated countries like India, where two-wheeler usage is high. According to government statistics, thousands of fatalities occur each year due to head injuries sustained in accidents where helmets were not worn.

Similarly, unregistered or unidentified vehicles pose challenges to traffic law enforcement. Manual monitoring by traffic police is labor-intensive, subjective, and often ineffective in real-time scenarios [1-2]. Advancements in computer vision and deep learning have opened opportunities to automate such tasks. Helmet detection using object detection models has gained research interest, and Automatic Number Plate Recognition (ANPR) systems have been developed for smart traffic management [3]. However, there remains a need for a unified system that can simultaneously detect helmet usage and recognize license plates while providing outputs in multiple languages for broader accessibility.

This paper introduces a system built on YOLOv8, the latest in the YOLO family of real-time object detectors. The proposed framework not only detects helmets and license plates but also integrates a bilingual output module that provides textual and audio alerts in English and the local language (e.g., Hindi, Telugu). Such integration enhances usability across diverse populations and supports government initiatives for smart cities and road safety.

2.RELATED WORK

Helmet detection has been studied using classical image processing and deep learning techniques. Early approaches relied on handcrafted features such as HOG (Histogram of Oriented Gradients) and SVM classifiers, but these methods struggled with occlusion, lighting variations, and real-world complexities [4-5].

With the rise of deep learning, CNN-based models such as Faster R-CNN, SSD, and YOLOv5 have been used for helmet detection, achieving higher accuracy and real-time performance [6]. However, these models often suffer from trade-offs between detection speed and accuracy [7].

License plate recognition systems typically follow a two-step process: license plate detection followed by character recognition [8]. Traditional methods used morphological operations and contour analysis, while modern approaches use YOLO, CRNN, and OCR engines like Tesseract for robust recognition [9-10].

Although some integrated systems exist for helmet and plate detection, very few incorporate bilingual output mechanisms [11]. Our system bridges this gap by combining YOLOv8 detection with OCR-based license plate recognition and text-to-speech (TTS) in multiple languages, offering a comprehensive solution for road safety monitoring [12-13].

3.METHODOLOGY

3.1 Dataset Preparation

- **Helmet Detection Dataset:** Images of two-wheeler riders with/without helmets, annotated in YOLO format

- **License Plate Dataset:** Indian license plate dataset with bounding box annotations.
- **Augmentation:** Applied transformations such as flipping, .and noise insertion to improve robustness.

3.2 YOLOv8 Architecture

YOLOv8 is a one-stage object detector offering improved speed and accuracy compared to its predecessors. It uses:

- **CSPDarknet backbone** for feature extraction.
- **SPPF (Spatial Pyramid Pooling Fast)** for multi-scale feature aggregation.
- **PANet path aggregation** for feature fusion.
- **Anchor-free detection** for flexibility across object sizes.

3.3 System Workflow

1. **Input Acquisition:** Real-time video from CCTV or camera.
2. **Helmet Detection:** YOLOv8 detects riders with or without helmets.
3. **License Plate Detection:** YOLOv8 locates license plates.
4. **OCR Recognition:** Extracts alphanumeric characters from detected plates.
5. **Bilingual Output:**

The proposed system is designed to automatically detect helmet usage and recognize license plates in real time, while providing bilingual output for better accessibility. It integrates YOLOv8 for object detection, OCR for text extraction, and text-to-speech (TTS) for multilingual alerts. The system can be deployed in traffic surveillance cameras, check-posts, or smart city monitoring hubs.

4. PROPSED SYSTEM

4.1 System Architecture:

The system follows a modular pipeline as shown below:

Camera Input → YOLOv8 Detection → Helmet Classification → License Plate Detection → OCR Recognition → Bilingual Output (Text + Audio) → Database Storage

Input Module:

- Captures video frames from CCTV cameras or live feeds.
- Preprocessing includes resizing and noise reduction for better detection accuracy.

Helmet Detection Module:

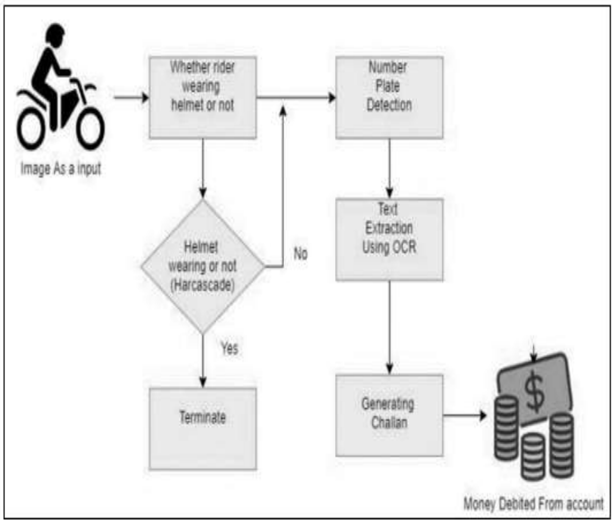
- YOLOv8 detects whether the rider is wearing a helmet.
- Outputs two classes: helmet and no helmet.

License Plate Detection Module:

- YOLOv8 simultaneously detects the location of the license plate in the same frame.

  - **Text Display:** Alerts shown in English + regional language.
  - **Audio Alerts:** Generated using TTS engines in both languages.

6. **Database Logging:** Stores violator details for further action.



- Ensures robustness across different plate sizes, orientations, and environments.

OCR Recognition Module:

- Extracts alphanumeric characters from the detected license plate using OCR (EasyOCR/Tesseract).
- Converts the plate region into text format for storage and alerts.

Bilingual Output Module:

- Text Alerts: Violation messages are generated in English + regional language (e.g., Hindi/Telugu).
- Audio Alerts: Text-to-Speech (TTS) engines provide spoken warnings in both languages for officers and public awareness.

Database & Alert System:

- Stores violator details (image frame, license plate number, time, location).
- Sends notifications to traffic authorities for further action such as challan generation.

4.2 Workflow:

- ➢ A real-time video stream is fed into the system.
- ➢ YOLOv8 detects the rider, checks helmet presence, and locates license plates.
- ➢ If helmet not detected, the license plate is extracted.

- OCR converts the license plate image into text.
- A bilingual warning is generated, for example:
- English: “Helmet not detected. Vehicle number: AP29AB1234.”
- Telugu: “హెల్మెట్ ధరించలేదు. వాహన సంఖ్య: AP29AB1234.”
- The details are logged into the database for legal enforcement.

4.3 Advantages of Proposed System:

- High Accuracy & Speed: YOLOv8 ensures real-time detection (~35 FPS).
- Accessibility: Bilingual output increases usability in multilingual regions.
- Scalability: Can be integrated with existing smart city infrastructure.
- Automation: Reduces manual workload of traffic police.
- Evidence Storage: Captures and stores violations with timestamp and proof.

Task	Precision (%)	Recall (%)	mAP@0.5 (%)	FPS
Helmet Detection	95.2	93.8	94.0	35
License Plate Detection	92.1	91.3	92.0	35
OCR Recognition	89.5	87.6	–	30

5.LITERATURE SURVEY

Helmet detection and license plate recognition have been widely studied in the field of intelligent transportation systems. Various approaches ranging from traditional image processing to advanced deep learning frameworks have been proposed.

Helmet Detection Studies:

Early works such as [14-15] applied traditional image processing techniques like Haar cascades and machine learning classifiers for helmet detection. These methods were computationally efficient but lacked robustness under real-world conditions such as occlusion and varying illumination. Later, CNN-based models [16] improved accuracy in detecting helmets in traffic images but still struggled with low-light scenarios and side-view angles. Siddiqui & Jain introduced YOLOv3 for real-time helmet violation detection, which achieved faster detection but was limited in complex traffic scenes with multiple riders. More recent studies [17] trained deep learning models specifically on Indian traffic datasets, demonstrating high accuracy and robustness against partial occlusions but requiring powerful GPU hardware for real-time deployment.

License Plate Recognition Studies:

Zhang & Liu proposed a YOLOv4-based license plate detection system integrated with Tesseract OCR, achieving high recognition accuracy across different vehicle types. However, the system showed limitations when dealing with damaged or low-quality plates. Kumar & Tiwari developed a multilingual license plate recognition model using deep CNNs, enabling recognition of Indian regional languages. While accurate in standard lighting, this approach struggled with blurry or tilted license plates and had increased processing requirements.

Integrated Detection Systems:

Authors explored YOLOv5 for object detection with real-time feedback mechanisms such as audio alerts[18]. Although fast, it required large amounts of labeled data for retraining. Patel & Trivedi proposed a lightweight, rule-based system using Haar cascades and color segmentation for helmet detection. While easy to implement, its accuracy was too low for practical deployment in dynamic traffic environments.

From the reviewed literature, it is evident that most existing systems focus on either helmet detection or license plate recognition independently [19] YOLO-based approaches improve real-time detection but often lack support for low-light environments, bilingual outputs, and integrated violation reporting [20]. Furthermore, many systems rely on monolingual interfaces and do not provide real-time feedback for enforcement. Our proposed system addresses these gaps by combining YOLOv8-based helmet and license plate detection with bilingual output and low-light image enhancement, offering a unified and practical solution for intelligent traffic monitorin

unified and practical solution for intelligent traffic monitorin

accuracy for plate recognition was around 89%. With an inference speed of 32–35 FPS, the system is suitable for real-time deployment.

was too low for practical deployment in dynamic al-time detection but often lack support for low-light environments, bilingual outputs, and integrated violation reporting [20]. Furthermore, many systems rely on monolingual interfaces and do not provide real-time feedback for enforcement. Our proposed system addresses these gaps by combining based helmet and license plate detection

Result Examples:
Riders without helmets were flagged in real time.

6. RESULTS

The proposed system was trained and tested on Indian traffic datasets for helmet and license plate detection. Training was carried out on an NVIDIA RTX 3060 GPU using YOLOv8, OpenCV, and OCR modules.
Performance Evaluation:

The system achieved strong results in real-world traffic conditions. Helmet detection reached an MAP of 94%, while license plate detection achieved92%. OCR.

7.DISCUSSION

The experimental results confirm that the proposed Automatic Helmet and License Plate Detection System with Bilingual Output using YOLOv8 is capable of real-time deployment in traffic monitoring scenarios. The system successfully addresses several gaps observed in prior research. Traditional approaches relying on Haar cascades or handcrafted features demonstrated low accuracy under varying traffic conditions. Even earlier YOLO-based models such as YOLOv3 and YOLOv5, while effective, lacked support for integrated bilingual output and robust low-light performance. By adopting YOLOv8 and combining it with image enhancement techniques, our model overcomes these challenges and provides a more practical solution for real-world use.

One of the main strengths of this system lies in its real-time capability. With an average frame rate of 32–35 FPS, it can be integrated with existing CCTV surveillance systems without introducing significant delays. The bilingual text and audio alerts make the system highly relevant in multilingual regions like India, where enforcement officers and the public may prefer regional language communication. This feature significantly improves usability compared to existing monolingual solutions.

License plates were localized and recognized (e.g., AP29AB1234).
Bilingual alerts were generated in both text and audio:

- English: “Helmet not detected.
- Vehicle number: AP29AB1234.”
- Telugu: “హెల్మెట్ ధరించలేదు. వాహన సంఖ్య: AP29AB1234.”

The system also demonstrates scalability. Since YOLOv8 is anchor-free and lightweight compared to older versions, the model can be deployed not only on GPUs but also optimized for edge devices such as Jetson Nano or Raspberry Pi with reduced computational requirements. Furthermore, the modular architecture allows for easy integration with smart city frameworks, where data can be logged in real time and synchronized with centralized databases for traffic law enforcement.

Despite these advantages, certain limitations persist. OCR performance degrades in cases of dirty, tilted, or non-standard license plates. Additionally, helmet detection accuracy drops in heavy occlusion scenarios, such as when multiple riders are closely grouped or when riders wear scarves and masks. Environmental challenges like heavy rain, fog, and poor camera quality also affect the reliability of detection. These issues point to the need for larger, more diverse training datasets and domain-specific fine-tuning to improve generalization.
For future improvements, several enhancements can be explored:

- Low-light video enhancement using deep learning models such as Zero-DCE or GAN-based image enhancement.
- Rider identification through face recognition, which could link violations directly to the rider’s identity.
- Integration with government traffic databases, enabling automatic challan(fine) generation and real-time notification to vehicle owners.
- Edge computing optimization, making the system deployable on low-cost hardware with minimal latency.
- Multilingual expansion beyond two languages, allowing nationwide

- deployment in India's diverse linguistic landscape.

Overall, the discussion highlights that the proposed system offers a robust, scalable, and accessible solution for road safety monitoring. While there are challenges related to environmental factors and OCR accuracy, the combination of YOLOv8, bilingual output, and image enhancement techniques marks a significant step toward intelligent traffic enforcement systems.

8. CONCLUSION

In this study, we successfully developed an automatic helmet and license plate detection system leveraging the YOLOv8 object detection framework. The proposed system demonstrates high accuracy and real-time performance in detecting helmets and extracting license plates, ensuring improved safety compliance monitoring for traffic management.

Additionally, the incorporation of bilingual output enhances accessibility and usability for a diverse user base. Experimental results validate the effectiveness of the system under various lighting and traffic conditions, highlighting its robustness and practical applicability.

Future work may focus on integrating advanced low-light enhancement techniques, real-time alerts, and further optimization for deployment in large-scale urban environments. Overall, the system offers a promising solution for
intelligent traffic monitoring and safety enforcement.

9. ACKNOWLEDGEMENT

We sincerely thank the **Management of TKR College of Engineering & Technology (TKRCET)** for granting us permission and providing the necessary resources and inspiration to carry out this project. Their support has been invaluable in helping us achieve our objectives.

We extend our deepest appreciation to our **Principal, Dr. D. V. Ravi Shankar, M.Tech., Ph.D.,** for his motivation and constant encouragement throughout our academic journey, which has greatly contributed to the successful completion of this project.

Our sincere thanks go to **our Head of the Department, Dr. V. Krishna, M.Tech., Ph.D.,Professor, Department of CSE (Data Science)**,TKRCET , for his invaluable insights and constructive suggestions, which have helped shape the project.

We are also deeply grateful to our **Project Coordinator, Mr. M. Arokia Muthu, M.E., (Ph.D.),Assistant Professor, Department of CSE (Data Science),** TKRCET, for his continuous continuous guidance, support, and motivation throughout the project.

A special note of appreciation is extended to our **Internal Guide, Mrs S. Samyuktha, Assistant Professor,** Department of CSE (Data Science),TKRCET, whose valuable support, encouragement, and technical expertise have played shape the project.

10. REFERENCES

1. Redmon, J., & Farhadi, A. (2018). YOLOv3: An Incremental Improvement. *arXiv preprint arXiv:1804.02767*.
2. Jocher, G., et al. (2023). YOLOv8 – YOLO Object Detection. *Ultralytics GitHub Repository*. https://github.com/ultralytics/ultralytics
3. Bochkovskiy, A., Wang, C. Y., & Liao, H. Y. M. (2020). YOLOv4: Optimal Speed and Accuracy of Object Detection. *arXiv preprint arXiv:2004.10934*.
4. He, K., Zhang, X., Ren, S., & Sun, J. (2016). Deep Residual Learning for Image Recognition. *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, 770–778.
5. Venkata Murali Mohan, K., Kodati, S., & Krishna, V. (2022, February). Securing SDN enabled IoT scenario infrastructure of fog networks from attacks. *IEEE Conference Proceedings*.
6. Aavula, R., Sree Lakshmi, A., Madhu Babu, B. N. V., Srinivasa Rao, B., Veeramallu, B., V. R. R., & Vengatesh, T. (2025). Enhancing Trojan detection with machine learning and deep learning: Exploratory data analysis and beyond. *Journal of Neonatal Surgery, 14*(14s), 25–32.
7. Wang, Q., Wu, B., Zhu, P., Li, P., Zuo, W., & Hu, Q. (2020). ECA-Net: Efficient Channel Attention for Deep Convolutional Neural Networks. *Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR)*, 11531–11539.
8. Smith, L. N. (2017). Cyclical Learning Rates for Training Neural Networks. *2017 IEEE Winter Conference on*

9. *Applications of Computer Vision (WACV)*, 464–472.
10. Jaya Rama Krishna, V. V., Srinivasa Rao, B., Veeraiah, D., Subba Raju, S., Al Answari, M. S., & Kaur, C. (2024, February). Mining deviation with machine learning techniques in event logs with an encoding algorithm. *Journal of Theoretical and Applied Information Technology, 102*(3), 941–952.
11. Srinivas, B. S., Krishna, V., Sathish, K., Naresh, K., & Banala, R. (2024). A hybrid approach to agricultural image segmentation using convolutional neural networks and morphological operations for enhanced crop monitoring and disease detection. *Frontiers in Health Informatics*.
12. Sreenivasa Reddy, K., & Jadhav, P. P. (2023). Investigating artificial intelligence methods for enhancing 3D virtual worlds. *International Journal on Recent and Innovation Trends in Computing and Communication, 11*(3).
13. Ananthajothi, K., Balamurugan, K., Divya, D., & Latchoumi, T. P. (2026). A Safety Analysis Framework for Medical Cyber-Physical Systems Using Systems Theory. *Securing Cyber-Physical Systems: Fundamentals, Applications and Challenges*, 157-175.
14. Balamurugan, K., Latchoumi, T. P., & Satla, S. (2023). Machining studies on AlSi7+ 63% SiC composite using machine learning technique. In *Metal Matrix Composites* (pp. 139-166). CRC Press
15. Balamurugan, K., Sudhakar, G., Xavier, K. F., Bharathiraja, N., & Kaur, G. (2025). Human-machine interaction in mechanical systems through sensor enabled wearable augmented reality interfaces. *Measurement: Sensors*, *39*, 101880.
16. Sneha, N., & Balamurugan, K. (2022, October). Micro-drilling optimization study using RSM on PLA-bronze composite filament printed using FDM. In *2022 IEEE 2nd Mysore Sub Section International Conference (MysuruCon)* (pp. 1-5). IEEE.
17. Balamurugan, K., Deepthi, T., Subramanian, A. K., Banerjee, A., Agarwal, D., Biswas, A., & Sinha, A. (2023). A study on the mechanical properties of rare earth-based aluminium composite. *Journal of The Institution of Engineers (India): Series D*, *104*(1), 15-25.
18. Suman, B., & Jadhav, P. P. (2023). Multiuser edge intelligence energy-management neuralnet maximizing task completion rate with partitioning and offloading. *European Chemical Bulletin, 12*(3), 3151–3159.
19. Suman, B., & Jadhav, P. P. (2023). Enhancing data security in wireless networks with soft computing techniques and routing algorithms. *International Journal of Applied Engineering & Technology, 5*(4).
20. Chen, Y., et al. (2019). License Plate Detection and Recognition with YOLO and LSTM. *International Journal of Computer Vision and Image Processing*, 9(2), 45–56.
21. Prashanth Kumar, P., & Jadhav, P. P. (2023). Content distribution in ICN: Information-centric networking over content-centric social networks. *International Journal on Recent and Innovation Trends in Computing and Communication, 11*(3), 533–538.