International Journal of Engineering Technology and Management Science
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.120 ISSN: 2581-4621

DRIVER ASSISTANCE: ENHANCED SAFETY WITH ROAD SIGNS AND HAND GESTURES RECOGNITION

Dr. G. Sivakumar[1], D Aravind[2], B John william[3], S Karthigai pandi[4]
[1] *Professor, B.E. Computer Science and Engineering, Erode Sengunthar Engineering College,* Erode, India
[2, 3, 4] *Student, B.E. Computer Science and Engineering, Erode Sengunthar Engineering College,* Erode, India

ABSTRACT
Ensuring driver safety and enhancing communication between vehicles and humans is becoming increasingly critical in today's evolving transportation systems. This paper, titled "Driver Assistance: Enhanced Safety with Road Signs and Hand Gestures," presents an integrated approach that leverages state-of-the-art deep learning techniques to improve vehicle interaction and safety. By combining the YOLO (You Only Look Once) object detection model with Convolutional Neural Networks (CNNs) for classification, the system can accurately detect and interpret road signs and hand gestures in real time. The YOLO model efficiently identifies the location of road signs and hand gestures within images, while the CNN component provides a detailed classification to determine the specific type and meaning of each detected object. To ensure the system's robustness, a diverse dataset comprising various road signs and hand gestures captured under different environmental conditions is used. The system analyzes key visual features, such as shape, color, and patterns, allowing it to recognize traffic signs like stop signs, speed limits, and warning signals, as well as interpret hand gestures for vehicle control. Performance is evaluated using metrics such as precision, recall, F1-score, and overall accuracy, showcasing the system's high accuracy and reliability. With its potential to be integrated into both autonomous and semi-autonomous vehicles, the proposed solution could significantly enhance traffic safety and improve the way drivers interact with their vehicles. This work lays the groundwork for the future development of intelligent transportation systems and advanced driver assistance technologies, ultimately contributing to safer roads and more efficient vehicle operations.
Keywords — *Road Sign Detection, Hand Gesture Recognition, Convolutional Neural Network (CNN), YOLO, Object Detection, Image Processing, Traffic Sign Classification, Driver Assistance Systems, Real-Time Recognition, Autonomous Driving, Human-Machine Interaction, Data Augmentation, Deep Learning Models, Safety Enhancement.*

International Journal of Engineering Technology and Management Science
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.120 ISSN: 2581-4621

I. Introduction

The rapid advancement of autonomous driving and technologies that improve the interaction between humans and machines are developing at an incredible pace. Alongside this growth, the need for systems that can accurately recognize road signs and hand gestures is becoming more important than ever. These systems are critical for boosting road safety, ensuring smooth communication between vehicles and drivers, and keeping drivers compliant with traffic laws. Road signs provide essential information to drivers, such as speed limits, directions, and alerts about potential hazards, while hand gestures enable intuitive vehicle control and signaling, making driving easier and more interactive.

But building a reliable system that can detect road signs and hand gestures in real-time is not without its challenges. The system must function well under various conditions, like changes in lighting, different viewing angles, varying weather conditions, and potential obstructions. Traditional methods have relied on rule-based approaches or manually crafted features, but these methods often fall short in dynamic driving environments. They are time-consuming, require a lot of manual input, and fail to perform consistently across different real-world situations.

With this in mind, it has become clear that a smarter, more adaptable solution is needed one that can automatically recognize road signs and hand gestures even in challenging conditions. Recent advancements in deep learning and computer vision have paved the way for more sophisticated approaches. Models like Convolutional Neural Networks (CNNs) and object detection frameworks, such as YOLO (You Only Look Once), have proven highly effective at detecting and localizing objects within images at high speed and with great accuracy. These models can learn features directly from data, allowing them to handle the wide variety of road signs and hand gestures they encounter in different settings.

II. Existing System

Traditional Advanced Driver Assistance Systems (ADAS) often focus on individual functions, such as road sign recognition or lane departure warnings, without integrating hand gesture recognition. While some in-car gesture-based control systems exist for tasks like adjusting volume, these systems generally do not interpret crucial external gestures, such as signals from traffic police. This lack of combined road sign and hand gesture recognition limits the ability of ADAS to offer comprehensive driving safety. Furthermore, many current systems struggle to maintain accuracy under challenging conditions, such as poor weather or low lighting, and often rely on costly hardware, making them less accessible for widespread use.

Challenges in the Existing System

1. Limited Focus

- Traditional ADAS systems typically address one function (e.g., road sign recognition or lane departure warnings) without integrating hand gesture recognition, missing comprehensive afety cues.

2. Lack of External Gesture Recognition

- While some systems detect in-car gestures for controls like volume adjustment, they do not interpret external gestures, such as signals from traffic police.

3. Incomplete Safety Coverage

- The absence of combined road sign and hand gesture recognition limits the overall effectiveness of ADAS for driving safety.
- Existing systems may struggle with accuracy in adverse conditions (e.g., low light, rain, fog).

III. Proposed System

The Driver Assistance system aims to address limitations in current ADAS technology by creating a fully integrated solution that combines road sign and hand gesture recognition into one cohesive system. Using Convolutional Neural Networks (CNNs), the system will enable real-time detection

International Journal of Engineering Technology and Management Science
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.120 ISSN: 2581-4621

and classification of road signs, while a hybrid model of CNNs and Recurrent Neural Networks (RNNs) will accurately interpret hand gestures. Designed for edge computing, the system is optimized for low-latency performance, making it suitable for in-car deployment without sacrificing speed or accuracy. Additionally, a user-friendly interface will deliver clear and timely alerts to enhance driver awareness and responsiveness to road signals and instructions. Adaptability to different environmental conditions will further ensure the system's reliability, providing effective support in varied driving scenarios.

Key Features of the Proposed System

1. Integrated Solution

- Combines road sign and hand gesture recognition in one system, providing comprehensive driver assistance.

2. Real-Time Performance

- Utilizes CNNs and RNNs for accurate, real-time detection and classification, enhancing response time.

3. Optimized for Edge Devices

- Designed for low-latency operation on edge computing devices, making it suitable for in-car deployment.

4. User-Friendly Alerts

- Provides clear and timely alerts to improve driver awareness and reaction to road signals and instructions

IV. IMPLEMENTATION

The Driver Assistance System is structured into two primary modules: the Road Sign Detection Module and the Hand Gesture Detection Module. These modules utilize deep learning models, computer vision techniques, and real-time processing to assist drivers with real-time sign recognition and gesture interpretation. The system is optimized for low-latency performance on edge computing devices, ensuring effective deployment in real-world driving conditions.

A. Road Sign Detection

The Road Sign Detection Module is responsible for identifying and classifying traffic signs in real-time using a deep learning model. The system captures images through two approaches: manual uploads and live video feed from a camera. The acquired image undergoes preprocessing to ensure compatibility with the deep learning model. This includes resizing to 300×300 pixels, normalization, and contrast enhancement to improve detection accuracy under varying environmental conditions.

A Convolutional Neural Network (CNN), trained on a labeled dataset of traffic signs, is employed for classification. The system uses the YOLO (You Only Look Once) object detection algorithm for efficient real-time localization of signs, allowing fast and accurate detection of regulatory, warning, and guide signs. When a sign is detected, the model outputs a probability score, and the class with the highest confidence is selected as the recognized traffic sign. The system supports multiple categories, including STOP, Speed Limit 30, No Parking, and Turn Right.

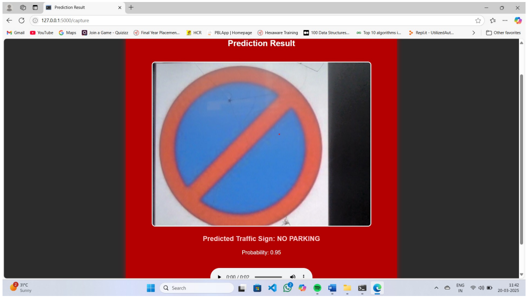
Real Time Image Scanner Fig (4.1)

To enhance driver awareness, an audio-based notification system is integrated using text-to-speech

International Journal of Engineering Technology and Management Science
Website: ijetms.in Issue: 2 Volume No.9 March - April – 2025
DOI:10.46647/ijetms.2025.v09i02.120 ISSN: 2581-4621

(TTS) technology. Upon detecting a traffic sign, the system generates a voice alert, informing the driver about the sign without requiring visual confirmation. This improves safety by ensuring that the driver receives instant notifications without distraction. Additionally, the module supports live video processing, where frames are continuously analyzed to monitor road signs dynamically.

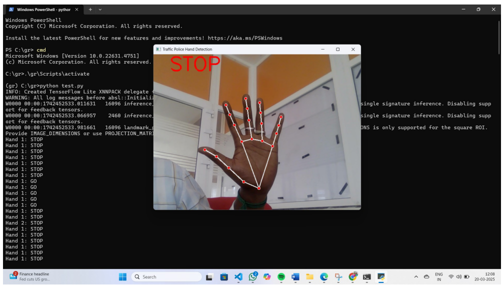
The system is optimized for deployment on embedded devices, including Jetson Nano and Raspberry Pi, allowing real-time detection with low computational overhead. For challenging environments such as low-light or foggy conditions, image enhancement techniques like Contrast Limited Adaptive Histogram Equalization (CLAHE) are applied to improve visibility. These optimizations ensure high reliability across diverse driving conditions, making the system a robust driver assistance tool.



Output Detection Fig (4.2)

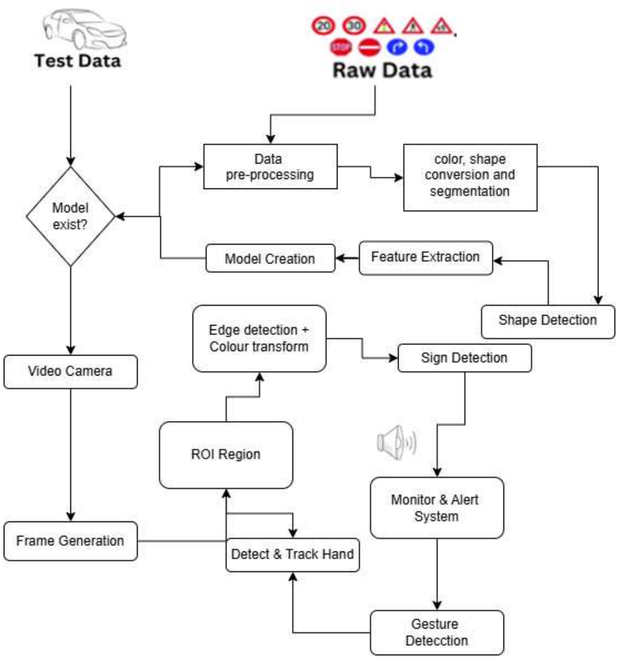
B.Hand Gesture Detection

The Hand Gesture Detection Module is designed to recognize traffic hand signals, particularly those made by traffic police officers and other drivers. The system continuously captures video input and processes frames to detect and classify hand gestures. The Media Pipe Hand Tracking framework is used to segment the hand region, extracting key features such as finger positions, palm orientation, and motion trajectories.



Hand Gesture [Stop Sign] Fig(4.3)

To recognize dynamic gestures, a hybrid deep learning model combining CNN and RNN architectures is utilized. The CNN extracts spatial features, while the RNN (LSTM/GRU) processes temporal movement patterns, ensuring accurate classification of hand gestures. The system is trained to recognize essential traffic gestures, including: Raised Palm (STOP Signal).



Flow Chart Fig (4.4)

V. Discussion

Integrating road sign detection and hand gesture recognition within driver assistance systems can significantly enhance road safety and improve driving experiences. By using deep learning models such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs), the system addresses several challenges that traditional methods face, particularly in adapting to varying real-world conditions and handling the complexity of different driving environments.

Road Sign Detection: CNNs play a crucial role in detecting road signs in real-time. Their ability to learn and automatically extract features from images makes them highly effective, even in challenging conditions like poor lighting or when signs are partially obstructed. Unlike older methods that depend on manually chosen features, CNNs dynamically adjust to diverse road signs, leading to improved detection accuracy and adaptability. Extensive training on large datasets has shown that these models perform exceptionally well, and their accuracy increases as more data is processed.

Hand Gesture Recognition: The system's use of hand gesture recognition adds a layer of convenience, allowing drivers to interact with the vehicle without physically touching controls. By combining CNNs for spatial analysis and RNNs for recognizing sequences over time, the system can understand and respond to complex gestures, such as signaling turns or stopping. However, a challenge remains in ensuring the system distinguishes between deliberate gestures and incidental hand movements. Further refinement of the system’s training and sensitivity can help reduce false detections and improve accuracy in recognizing driver intentions.

Real-Time Processing and Edge Computing: A critical aspect of the system is its ability to process information in real time, as any delay could compromise the safety of the driver. By optimizing the system to operate efficiently on edge computing devices, latency is reduced, enabling fast responses to both road signs and hand gestures. Edge computing also supports local data processing, ensuring continuous operation even when there is no access to the cloud or internet services. This makes the system particularly reliable in remote or network-limited areas.

Challenges and Environmental Adaptability: Despite its strengths, the system faces challenges in harsh environmental conditions such as heavy rain, fog, or nighttime driving. To counter these issues, advanced image enhancement techniques are incorporated to improve visibility. However, more development is needed to further strengthen the system’s performance in extreme weather

DOI:10.46647/ijetms.2025.v09i02.120 ISSN: 2581-4621

conditions. Similarly, hand gestures vary across cultures and regions, so it is important for the recognition system to be adaptable to different gesture patterns to provide consistent results across various driving environments.

Human-Machine Interaction: The effectiveness of the hand gesture recognition system also depends on how well it integrates with the human-machine interface (HMI) in the vehicle. Ensuring the system provides feedback that is simple and easy to understand is essential to reduce driver distraction. The more intuitive the interface is, the more likely it is to enhance the driving experience without overwhelming the driver with excessive information

Hand Gesture Recognition: The system's use of hand gesture recognition adds a layer of convenience, allowing drivers to interact with the vehicle without physically touching controls. By combining CNNs for spatial analysis and RNNs for recognizing sequences over time, the system can understand and respond to complex gestures, such as signaling turns or stopping. However, a challenge remains in ensuring the system distinguishes avenues for future development. Additionally, integrating features like driver fatigue monitoring could further enhance the system’s contribution to overall driving safety.

VI. CONCLUSION

This paper has developed a real-time system that effectively detects and classifies both road signs and hand gestures, using a combination of YOLO for fast detection and Convolutional Neural Networks (CNNs) for precise classification. By applying cutting-edge deep learning techniques, the system can identify road signs and interpret hand gestures accurately, even in challenging and dynamic driving conditions. YOLO’s ability to quickly detect objects, paired with the fine-tuned classification capabilities of CNNs, ensures that the system delivers high accuracy and minimal delay, making it highly suitable for integration into autonomous and semi-autonomous vehicles.

The results clearly show that this approach outperforms more traditional methods in terms of detection accuracy, classification detail, and real-time performance. Its ability to operate seamlessly with minimal lag is crucial for enhancing road safety and improving the communication between drivers and their vehicles. Overall, this system offers a powerful, reliable solution that can make a real impact on the future of safe and intelligent driving technology.

VII. REFERENCES

[1] Y. Sun, P. Ge and D. Liu, "Traffic Sign Detection and Recognition Based on Convolutional Neural Network," 2019 Chinese Automation Congress (CAC), Hangzhou, China, 2019, pp. 2851-2854, Doi:10.1109/CAC48633.2019.8997240.

[2] M. D. RADU, I. M. COSTEA and V. A. STAN, "Automatic Traffic Sign Recognition Artificial Intelligence - Deep Learning Algorithm," 2020 12th International Conference on Electronics, Computers and Artificial Intelligence (ECAI), 86203, 2022, Doi: 10.1109/ACCESS.2022.3198954.

[3] K. Naithani, D. Malik, P. Kumar, M. Bilal and M. Singh, "Computer Control with Hand Gestures using Machine Learning (ML) and Computer Vision," 2023 3rd International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), Bengaluru, India, 2023, pp. 571-576, Doi: 10.1109/ICIMIA60377.2023.10426275

[4] S. Jency, S. Karthika, J. Ajaykumar, R. Selvaraj and A. P. Aarthi, "Traffic Sign Recognition System for Autonomous Vehicles using Deep Learning," 2023 7th International Conference on Trends in Electronics and Informatics (ICOEI), Tirunelveli, India, 2023, pp. 1116-1121, Doi: 10.1109/ICOEI56765.2023.10125896.

[5] A. Sivasankari, S. Nivetha, Pavithra, P. Ajitha and R. M. Gomathi, "Indian Traffic Sign Board Recognition and Driver Alert System Using CNN," 2020 4th International Conference on Computer, Communication and Signal Processing (ICCCSP), Chennai, India, 2020, pp. 1-4, Doi: 10.1109/ICCCSP49186.2020.9315260.

[6] J. Zhao, X. H. Li, J. C. D. Cruz, M. S. Verdadero, J. C. Centeno and J. M. Novelero, "Hand Gesture Recognition Based on Deep Learning," 2023 International Conference on Digital

Applications, Transformation & Economy (ICDATE), Miri, Sarawak, Malaysia, 2023, pp. 250-254, Doi: 10.1109/ICDATE58146.2023.10248500.

[7] P. Raj, S. Pandey, Y. Singh and M. Singh, "Hand Sign & Gesture Recognition System," 2023 6th International Conference on Contemporary Computing and Informatics (IC3I), Gautam Buddha Nagar, India, 2023, pp. 639-642, Doi: 10.1109/IC3I59117.2023.10398116.

[8] E. Güney, C. Bayilmiş and B. Çakan, "An Implementation of Real-Time Traffic Signs and Road Objects Detection Based on Mobile GPU Platforms," in IEEE Access, vol. 10, pp. 86191-86203,2022,Doi:10.1109/ACCESS.2022.3198954.

[9] R. Hu, H. Li, D. Huang, X. Xu and K. He, "Traffic Sign Detection Based on Driving Sight Distance in Haze Environment," in IEEE Access, vol. 10, pp. 101124-101136, 2022, Doi: 10.1109/ACCESS.2022.3208108.

[10] R. P. Salim, [10] M. Atif, A. Ceccarelli, T. Zoppi, M. Gharib and A. Bonda Valli, "Robust Traffic Sign Recognition Against Camera Failures," in IEEE Open Journal of Intelligent Transportation Systems, vol. 3, pp. 709-722, 2022, Doi: 10.1109/OJITS.2022.3213183.

[11] S. Luo, C. Wu and L. Li, "Detection and Recognition of Obscured Traffic Signs During Vehicle Movement," in IEEE Access, vol. 11, pp. 122516-122525, 2023, Doi: 10.1109/ACCESS.2023.3329068.

[12] TQ. Gao, H. Hu and W. Liu, "Traffic Sign Detection Under Adverse Environmental Conditions Based on CNN," in IEEE Access, vol. 12, pp. 117572-117580, 2024, Doi: 10.1109/ACCESS.2024.3446990.

[13] N. Mohamed, M. B. Mustafa and N. Jomhari, "A Review of the Hand Gesture Recognition System: Current Progress and Future Directions," in IEEE Access, vol. 9, pp. 157422-157436, 2021, Doi: 10.1109/ACCESS.2021.3129650.

[14] C. Dewi, R. -C. Chen, Y. -C. Zhuang and W. E. Manongga, "Image Enhancement Method Utilizing YOLO Models to Recognize Road Markings at Night," in IEEE Access, vol. 12, pp. 131065-131081, 2024, Doi: 10.1109/ACCESS.2024.3440253.

[15] Q. Wang, X. Li and M. Lu, "An Improved Traffic Sign Detection and Recognition Deep Model Based on YOLOv5," in IEEE Access, vol. 11, pp. 54679-54691, 2023, Doi: 10.1109/ACCESS.2023.3281551.