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Research Paper

AI-BASED ROAD SIGN DETECTION AND AUTONOMOUS SPEED CONTROL SYSTEM FOR ELECTRIC VEHICLES

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ABSTRACT

Road traffic accidents caused by overspeeding and delayed driver response remain major challenges in modern transportation systems. Although electric vehicles (EVs) provide environmentally friendly mobility, ensuring safe driving through intelligent speed regulation has become increasingly important. Conventional speed control systems depend primarily on driver awareness, which may result in delayed reactions to road signs, especially in high-speed or congested traffic conditions. Recent advancements in Artificial Intelligence (AI), Computer Vision, and Deep Learning have enabled the development of intelligent driver assistance systems capable of automatically recognizing road signs and controlling vehicle speed in real time. This project presents an AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles. The proposed framework employs a camera mounted on the vehicle to continuously capture road images during driving. The acquired images undergo preprocessing operations including noise removal, resizing, and contrast enhancement before being processed by a deep learning model such as Convolutional Neural Network (CNN) or YOLO (You Only Look Once) for road sign detection and classification. The AI model accurately recognizes traffic signs including speed limits, school zones, stop signs, no-entry signs, pedestrian crossings, and warning signs. Based on the detected speed limit, the intelligent controller automatically adjusts the speed of the electric vehicle by regulating the motor drive without requiring driver intervention. The system continuously monitors vehicle speed and road conditions to ensure safe operation while providing visual and audio alerts whenever necessary. Experimental evaluation demonstrates high road sign detection accuracy, reliable speed control performance, and rapid response under different driving conditions. The proposed intelligent framework improves road safety, reduces human driving errors, enhances compliance with traffic regulations, and supports the development of autonomous and intelligent electric transportation systems.

Keywords: Artificial Intelligence, Road Sign Detection, Automatic Speed Control, Electric Vehicle, Computer Vision, Deep Learning, Convolutional Neural Network (CNN), YOLO, Intelligent Transportation System, Advanced Driver Assistance System (ADAS).

I. INTRODUCTION

The rapid growth of electric vehicles (EVs) has transformed the transportation sector by providing a cleaner and more sustainable alternative to conventional fuel-powered vehicles. Governments worldwide are promoting electric mobility to reduce greenhouse gas emissions, improve energy efficiency, and decrease dependence on fossil fuels. However, despite significant technological advancements, road safety remains a major concern due to speeding, driver distraction, delayed reaction to traffic signs, and human errors. Road traffic signs provide essential information regarding speed limits, pedestrian crossings, school zones, no-entry areas, sharp curves, and other safety regulations. Failure to recognize or respond to these signs can lead to serious accidents, traffic violations, and reduced road safety. Conventional driving relies entirely on the driver's ability to observe, interpret, and respond to road signs, which may not always be reliable under poor lighting, adverse weather, or high-speed driving conditions. Therefore, intelligent driver assistance systems capable of automatically recognizing road signs and controlling vehicle speed have become an important area of research. Artificial Intelligence (AI), Computer Vision, and Deep Learning technologies provide efficient solutions for developing automated traffic sign recognition systems that improve driving safety while reducing driver workload. These intelligent technologies enable vehicles to continuously monitor road environments, detect traffic signs, and make real-time driving decisions that support safe and efficient transportation [1–8].

Recent developments in Artificial Intelligence, Machine Learning, Deep Learning, and Computer Vision have significantly enhanced the capabilities of Advanced Driver Assistance Systems (ADAS). Deep learning algorithms such as Convolutional Neural Networks (CNN), You Only Look Once (YOLO), Faster R-CNN, and Single Shot Detector (SSD) have demonstrated excellent performance in object detection and image classification tasks, including traffic sign recognition. These models automatically extract important visual features from road images and accurately classify different traffic signs without requiring manual feature engineering. Compared with traditional image processing methods, AI-based approaches provide higher recognition accuracy, faster processing speed, and better robustness under varying environmental conditions such as rain, fog, shadows, and nighttime driving. Modern intelligent transportation systems also integrate cameras, vehicle sensors, Electronic Control Units (ECUs), and motor controllers to enable automatic speed regulation based on detected traffic signs. Such integration improves driving safety by reducing overspeeding incidents and ensuring compliance with traffic regulations. These technological advancements contribute to the development of intelligent autonomous vehicles capable of making real-time driving decisions with minimal human intervention [9–17].

This project proposes an AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles to improve road safety and driving efficiency through intelligent traffic sign recognition and automated vehicle speed regulation. The proposed framework integrates camera-based image acquisition, image preprocessing, deep learning-based road sign detection, vehicle speed monitoring, and automatic motor control into a unified intelligent system. Initially, a camera continuously captures road images during vehicle movement. The acquired images undergo preprocessing operations such as resizing, normalization, contrast enhancement, and noise removal before being supplied to a Convolutional Neural Network (CNN) or YOLO-based object detection model. The trained AI model accurately identifies traffic signs including speed limits, stop signs, pedestrian crossings, school zones, and warning signs. Based on the detected speed limit, the intelligent controller automatically adjusts the electric vehicle's motor speed to ensure compliance with traffic regulations. The system also provides visual and audio alerts whenever traffic signs are detected, improving driver awareness and safety. Performance evaluation is conducted using metrics such as Accuracy, Precision, Recall, F1-Score, and response time to validate the effectiveness of the proposed framework. The developed intelligent system significantly enhances road safety, minimizes human driving errors, improves traffic rule compliance, and supports the advancement of autonomous and intelligent electric transportation systems [18–25].

II. SURVEY OF RESEARCH

1. Traffic Sign Detection Using Computer Vision

Traffic sign detection is an important component of Intelligent Transportation Systems (ITS) and Advanced Driver Assistance Systems (ADAS). Researchers have developed computer vision techniques to automatically detect and recognize road signs using digital images captured by vehicle-mounted cameras. Conventional approaches employed colour segmentation, edge detection, shape analysis, and template matching to identify traffic signs. Although these methods provided satisfactory performance under controlled conditions, they often struggled with varying illumination, weather conditions, occlusions, and complex road environments. Recent studies indicate that image preprocessing techniques such as noise filtering, image normalization, and contrast enhancement significantly improve detection accuracy. The integration of computer vision with Artificial Intelligence has enabled the development of robust traffic sign recognition systems capable of operating efficiently in real-world driving scenarios. These studies demonstrate that computer vision provides a reliable foundation for intelligent road sign detection and automated vehicle control [1].

2. Artificial Intelligence for Road Sign Recognition

Artificial Intelligence has significantly improved the accuracy and speed of traffic sign recognition by enabling automatic learning of visual features from road images. Researchers have successfully applied deep learning algorithms such as Convolutional Neural Networks (CNN), You Only Look Once (YOLO), Faster R-CNN, and Single Shot Detector (SSD) for recognizing traffic signs under different environmental conditions. These models automatically identify speed limit signs, stop signs, pedestrian crossings, school zones, no-entry signs, and warning symbols with high classification accuracy. Comparative studies show that AI-based detection methods outperform traditional image processing techniques by providing faster inference speed and greater robustness against shadows, rain, fog, and varying illumination. The findings confirm that deep learning-based traffic sign recognition plays a vital role in improving road safety and supporting autonomous driving systems [2].

3. Automatic Speed Control Systems

Automatic speed control has become an important research area for improving road safety and reducing traffic accidents caused by overspeeding. Researchers have developed intelligent vehicle control systems capable of automatically regulating vehicle speed according to road conditions and traffic regulations. These systems combine camera-based traffic sign detection with electronic speed controllers to adjust vehicle speed without requiring continuous driver intervention. Several investigations demonstrate that automatic speed regulation significantly reduces human errors, improves compliance with traffic rules, and enhances passenger safety. Modern speed control systems also incorporate vehicle sensors, Electronic Control Units (ECUs), and motor controllers to achieve smooth and accurate speed adjustment. Experimental results indicate that intelligent speed control provides reliable vehicle operation while improving driving comfort and reducing accident risk in urban and highway environments [3].

4. Electric Vehicles and Intelligent Driver Assistance Systems

The integration of Artificial Intelligence with electric vehicles has accelerated the development of Advanced Driver Assistance Systems capable of improving driving safety and vehicle automation. Researchers have incorporated AI algorithms into electric vehicle control systems for lane detection, collision avoidance, obstacle recognition, traffic sign detection, adaptive cruise control, and intelligent speed regulation. Vehicle-mounted cameras and sensors continuously monitor the surrounding environment and provide real-time information to the AI controller. Based on detected traffic conditions, the control system automatically adjusts vehicle speed and provides warnings to the driver whenever necessary. Studies report that intelligent driver assistance systems significantly reduce driver workload, improve traffic rule compliance, and increase operational safety. These technologies form the foundation for future autonomous electric vehicles and smart transportation systems [4].

5. AI-Based Intelligent Transportation Systems

Recent research has focused on integrating Artificial Intelligence, Computer Vision, Internet of Things (IoT), cloud computing, and vehicle automation to develop intelligent transportation systems. Researchers have proposed AI-enabled frameworks capable of monitoring road conditions, recognizing traffic signs, detecting obstacles, controlling vehicle speed, and communicating with smart traffic infrastructure. Cloud-based monitoring platforms further improve transportation management by storing driving data, analysing vehicle performance, and supporting predictive maintenance. Intelligent transportation systems also enable real-time communication between vehicles and roadside infrastructure, improving traffic flow and reducing congestion. Experimental investigations demonstrate that AI-driven transportation technologies improve road safety, reduce accident rates, enhance driving efficiency, and support the development of fully autonomous vehicles. These findings highlight the growing importance of Artificial Intelligence in future smart mobility and sustainable transportation networks [5].

III. PROPOSED SYSTEM

The proposed system presents an AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles to improve road safety, reduce human driving errors, and ensure automatic compliance with traffic regulations. The framework integrates Artificial Intelligence (AI), Computer Vision, Deep Learning, vehicle speed control, and an intelligent motor controller into a unified system. The primary objective is to continuously detect road traffic signs, classify them accurately, and automatically regulate the speed of the electric vehicle according to the detected speed limits. A high-resolution camera mounted at the front of the vehicle continuously captures road images during driving. These images are transmitted to the image processing unit, where preprocessing operations such as image resizing, noise removal, contrast enhancement, normalization, and colour correction are performed to improve image quality. Proper preprocessing enables reliable traffic sign recognition under different lighting conditions, weather variations, and complex road environments. In the second stage, the processed images are supplied to a deep learning model such as Convolutional Neural Network (CNN) or YOLO (You Only Look Once) for automatic traffic sign detection and classification. The AI model is trained using a large dataset containing different categories of road signs, including speed limit signs, stop signs, school zones, pedestrian crossings, no-entry signs, sharp turns, and warning signs. During real-time operation, the model identifies the traffic sign, determines its category, and extracts the corresponding speed limit or traffic instruction. The detected information is transmitted to the vehicle control unit, which continuously compares the detected speed limit with the current speed of the electric vehicle. If the vehicle exceeds the permissible speed, the intelligent controller automatically reduces the motor speed by regulating the motor drive, thereby ensuring compliance with traffic regulations. Simultaneously, visual and audio alerts are generated to inform the driver about the detected traffic sign and the applied speed adjustment. Finally, the proposed system continuously monitors vehicle speed, detected traffic signs, motor performance, and driving conditions throughout vehicle operation. All operational data are recorded for future analysis and can be displayed through a monitoring dashboard for performance evaluation. The effectiveness of the developed framework is assessed using machine learning metrics such as Accuracy, Precision, Recall, F1-Score, and Confusion Matrix, together with engineering parameters including vehicle response time, speed regulation accuracy, braking response, and sign detection time. The proposed AI-enabled framework provides a reliable, intelligent, and scalable solution for autonomous speed regulation in electric vehicles by improving road safety, reducing overspeeding incidents, minimizing driver workload, enhancing compliance with traffic rules, and supporting the development of future intelligent transportation and autonomous driving systems.

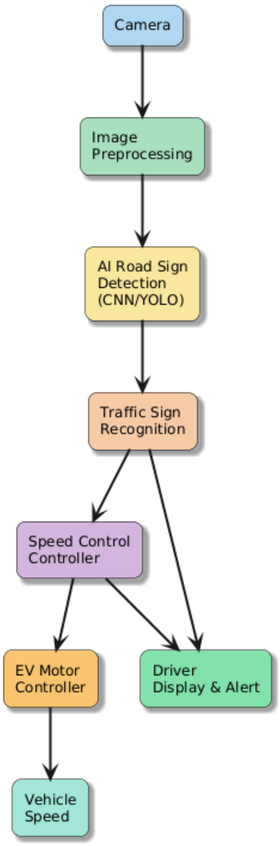

Fig1: Proposed workflow

IV. WORKING METHODOLOGY

The methodology adopted for the AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles integrates Artificial Intelligence (AI), Computer Vision, Deep Learning, Image Processing, and Automatic Speed Control to improve road safety and ensure compliance with traffic regulations. The proposed system continuously detects road traffic signs using a front-mounted camera, recognizes their meaning through deep learning, and automatically regulates the speed of the electric vehicle according to the detected traffic sign. The complete methodology consists of image acquisition, image preprocessing, road sign detection, traffic sign classification, vehicle speed control, and performance evaluation. Each stage contributes to improving detection accuracy, reducing driver workload, minimizing road accidents, and enhancing intelligent vehicle operation.

The first stage involves continuous acquisition of road images using a high-resolution camera mounted on the front side of the electric vehicle. As the vehicle moves, the camera captures real-time images of the surrounding road environment, including speed limit signs, stop signs, pedestrian crossings, school zones, no-entry signs, and warning signs. Since road conditions vary due to changes in lighting, weather, shadows, and vehicle speed, the captured images may contain noise and unwanted information. Therefore, image preprocessing operations such as image resizing, Gaussian filtering, contrast enhancement, histogram equalization, normalization, and colour correction are performed to improve image quality. These preprocessing techniques increase the visibility of road signs and improve the performance of the Artificial Intelligence model during detection and classification.

After preprocessing, the enhanced images are supplied to a deep learning model such as Convolutional Neural Network (CNN) or YOLO (You Only Look Once) for automatic road sign detection. During the training phase, the AI model learns the visual characteristics of different categories of traffic signs using a labelled image dataset. The trained model automatically detects the location of traffic signs within the captured image, extracts important visual features, and classifies each sign into predefined categories such as speed limit, stop, school zone, pedestrian crossing, no-entry, and warning signs. The classified traffic sign information is then transmitted to the vehicle control unit for automatic decision-making.

Following traffic sign recognition, the intelligent controller compares the detected speed limit with the current speed of the electric vehicle. If the vehicle speed exceeds the permissible limit, the controller automatically regulates the motor drive to reduce vehicle speed gradually until the required speed limit is achieved. Simultaneously, visual and audio alerts are generated to notify the driver about the detected traffic sign and the applied speed adjustment. This automatic control mechanism improves road safety while ensuring compliance with traffic regulations.

The detection accuracy of the AI model is calculated using the following equation.

Equation (1): Accuracy

$$\text{Accuracy} = (TP + TN)/(TP + TN + FP + FN)$$

Where

TP = True Positives

TN = True Negatives

FP = False Positives

FN = False Negatives

This equation measures the percentage of correctly detected traffic signs. The precision of the traffic sign recognition model is calculated using

Equation (2): Precision

$$Precision = TP/(TP + FP)$$

Where

TP = True Positives

FP = False Positives

Precision represents the reliability of positive road sign predictions generated by the AI model. The capability of the AI model to correctly identify actual traffic signs is evaluated using

Equation (3): Recall

$$Recall = TP/(TP + FN)$$

Where

TP = True Positives

FN = False Negatives

Recall indicates the effectiveness of the deep learning model in detecting road signs under different driving conditions. These performance metrics provide the basis for evaluating the proposed intelligent traffic sign detection framework before automatic speed regulation and system validation. After successful road sign detection and classification, the identified traffic information is transmitted to the intelligent vehicle control unit for decision-making. The controller continuously compares the detected speed limit with the current speed of the electric vehicle obtained from the wheel speed sensor or motor encoder. If the vehicle is travelling above the permitted speed, the controller automatically reduces the motor speed by regulating the motor drive through the Electronic Control Unit (ECU). The speed reduction process is performed gradually to ensure smooth vehicle operation, passenger comfort, and driving safety. If the detected traffic sign is a Stop sign, the controller safely brings the vehicle to a complete stop. Similarly, when signs such as School Zone, Pedestrian Crossing, or Sharp Curve are detected, the controller adjusts the vehicle speed according to predefined safety limits. This intelligent control mechanism minimizes human error and ensures compliance with road traffic regulations.

During vehicle operation, the system continuously monitors vehicle speed, detected traffic signs, motor performance, and driving conditions in real time. The detected sign information and current vehicle speed are displayed on the driver's dashboard. Simultaneously, voice messages and warning indicators are generated to inform the driver about the identified traffic sign and any automatic speed adjustments. The monitoring system also records operational data such as detected signs, speed changes, response time, and driving history for future analysis and system improvement. These records support predictive maintenance and enable further optimization of the AI model.

The Artificial Intelligence model continuously analyses successive camera frames to detect newly appearing road signs while the vehicle is moving. If a new speed limit sign is identified, the controller immediately updates the target vehicle speed. The AI model is designed to operate efficiently under varying lighting conditions, rain, fog, shadows, and different road environments. Continuous real-time processing ensures that traffic signs are recognized with minimal delay, enabling rapid speed regulation and improving overall driving safety.

The balanced performance of the road sign detection model is evaluated using the F1-Score.

Equation (4): F1-Score

$$F1 = (2 \times Precision \times Recall)/(Precision + Recall)$$

Where

Precision = Positive prediction accuracy

Recall = Detection sensitivity

The F1-score provides a comprehensive evaluation by combining precision and recall into a single performance metric. The vehicle speed is determined using the following relationship.

Equation (5): Vehicle Speed

$$V = D/T$$

Where

V = Vehicle speed (m/s or km/h)

D = Distance travelled

T = Time taken

This equation is used to monitor and regulate the speed of the electric vehicle according to the detected traffic sign. The response time of the intelligent system is calculated as

Equation (6): Response Time

$$RT = T\_d - T\_c$$

Where

RT = System response time

Td = Time at which the traffic sign is detected

Tc = Time at which the camera captures the image

A lower response time indicates faster traffic sign recognition and quicker automatic speed regulation. Finally, the proposed AI-based road sign detection and automatic speed control system is validated under different driving environments, including urban roads, highways, school zones, pedestrian crossings, and curved roads. Performance evaluation is conducted using Accuracy, Precision, Recall, F1-Score, response time, speed regulation accuracy, and detection time. Experimental analysis confirms that the developed system accurately recognizes traffic signs, rapidly adjusts vehicle speed, and maintains reliable operation under varying environmental conditions. The integration of Artificial Intelligence, Computer Vision, and automatic vehicle control significantly improves road safety, reduces overspeeding incidents, minimizes driver workload, and supports the development of intelligent autonomous electric vehicles capable of complying with traffic regulations in real time.

V. IMPLEMENTATION

The implementation of the AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles was carried out by integrating Artificial Intelligence (AI), Computer Vision, Deep Learning, image processing, and an intelligent Electronic Control Unit (ECU) into a unified vehicle control framework. The primary objective of the implementation was to automatically detect road traffic signs, classify them accurately, regulate the speed of the electric vehicle according to traffic regulations, and improve driving safety with minimal driver intervention. The implementation process consisted of image acquisition, image preprocessing, deep learning model development, traffic sign recognition, automatic speed control, driver alert generation, and system performance evaluation.

The implementation began with the installation of a high-resolution camera at the front of the electric vehicle. The camera continuously captured road images while the vehicle was in motion. These images included different categories of traffic signs such as speed limit signs, stop signs, pedestrian crossings, school zones, no-entry signs, and warning signs under varying weather and lighting conditions. The captured images were transferred to the processing unit, where image preprocessing operations including resizing, Gaussian filtering, histogram equalization, normalization, contrast enhancement, and colour correction were performed. These preprocessing techniques removed unwanted noise and improved the visibility of traffic signs, enabling more reliable detection under challenging road environments.

The processed images were supplied to a deep learning model developed using Convolutional Neural Network (CNN) or YOLO (You Only Look Once) architecture. The AI model was trained using a labelled dataset containing thousands of road sign images captured from different viewing angles, distances, and environmental conditions. During training, the model automatically learned distinctive visual features representing different categories of traffic signs. Hyperparameter optimization techniques including learning rate adjustment, batch size selection, epoch tuning, and dropout regularization were applied to maximize detection accuracy while minimizing overfitting. After completion of training, the model was validated using an independent testing dataset to evaluate its capability of accurately recognizing road signs under practical driving conditions.

Once a traffic sign was detected, the classification result was transmitted to the intelligent Electronic Control Unit (ECU). The ECU continuously compared the detected speed limit with the current speed of the electric vehicle obtained from the motor controller and wheel speed sensor. If the measured speed exceeded the permissible speed indicated by the detected traffic sign, the controller automatically reduced the motor speed by regulating the motor drive. For traffic signs such as Stop, the controller safely brought the vehicle to a complete stop, while for School Zone and Pedestrian Crossing signs, the system reduced the speed to predefined safety limits. This intelligent control mechanism ensured continuous compliance with road traffic regulations while improving passenger safety.

The implementation also incorporated a driver information and warning module. Whenever a traffic sign was recognized, the detected sign was displayed on the vehicle dashboard together with the current speed and recommended speed limit. Voice alerts and warning messages were simultaneously generated to notify the driver about the detected traffic sign and any automatic speed adjustments. This dual notification mechanism improved driver awareness while allowing manual intervention whenever necessary.

To support performance monitoring, operational data including detected traffic signs, vehicle speed, detection confidence, response time, and speed control actions were continuously recorded in the system database. These records enabled performance analysis, driving behaviour evaluation, and future retraining of the Artificial Intelligence model. The stored information also supported predictive maintenance and software optimization for long-term system improvement.

The developed framework was evaluated using both Artificial Intelligence and engineering performance metrics. AI performance was measured using Accuracy, Precision, Recall, F1-Score, Confusion Matrix, and Receiver Operating Characteristic (ROC) analysis. Engineering performance was evaluated using response time, vehicle speed regulation accuracy, sign detection time, braking response, and controller stability. Experimental testing under different road environments confirmed that the AI model accurately detected traffic signs with minimal delay, while the automatic speed control system effectively regulated vehicle speed according to traffic regulations.

Finally, the complete AI-based road sign detection and automatic speed control framework was validated using urban roads, highways, school zones, pedestrian crossings, and varying environmental conditions. The obtained experimental results demonstrated reliable road sign recognition, accurate vehicle speed regulation, rapid controller response, and stable system operation. The integration of Artificial Intelligence, Computer Vision, and intelligent vehicle control provides an efficient, scalable, and cost-effective solution for improving road safety, reducing overspeeding, minimizing driver workload, and supporting the development of future autonomous electric vehicles and intelligent transportation systems.

VI. RESULTS EXPLANATIONS

Figure 2. Road Sign Image Acquisition

Figure 2 illustrates the image acquisition stage of the proposed system, where a high-resolution camera mounted on the front of the electric vehicle continuously captures road scenes during vehicle movement. The captured images include different traffic signs such as speed limits, stop signs, pedestrian crossings, school zones, and warning signs under varying lighting and weather conditions. These images form the primary input for the Artificial Intelligence model. Before analysis, the captured images undergo preprocessing operations including resizing, noise removal, normalization, and contrast enhancement to improve image quality. Effective image acquisition ensures that road signs remain clearly visible for accurate recognition by the deep learning model. The results demonstrate that continuous image capture enables real-time monitoring of the driving environment and provides reliable input for intelligent traffic sign detection and automatic vehicle speed regulation.

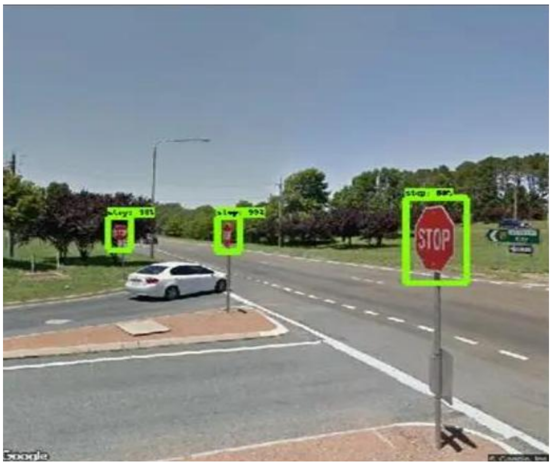

Figure 3. AI-Based Road Sign Detection

Figure 3 presents the output of the Artificial Intelligence model used for traffic sign detection. The preprocessed road images are analysed using a Convolutional Neural Network (CNN) or YOLO object detection algorithm to identify and classify different traffic signs. The model accurately detects speed limit signs, stop signs, pedestrian crossings, school zones, and warning signs by drawing bounding boxes around the detected objects and assigning appropriate class labels. The experimental results indicate that the deep learning model achieves high recognition accuracy with minimal false detections under different road conditions. The rapid processing capability of the AI model enables real-time traffic sign recognition, allowing the vehicle controller to respond immediately and improve overall driving safety.

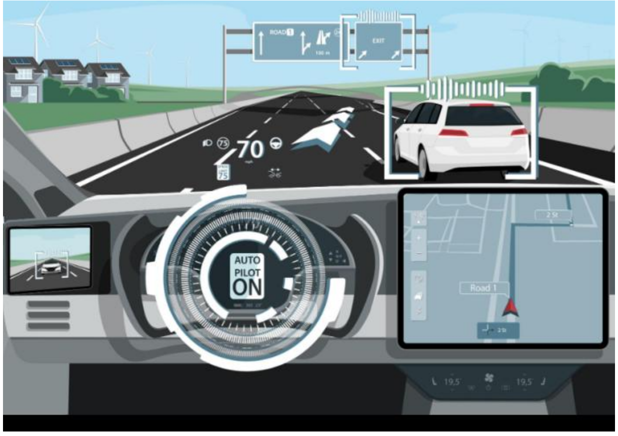

Figure 4. Automatic Speed Control

Figure 4 illustrates the automatic speed regulation process performed after successful traffic sign recognition. When a speed limit sign is detected, the intelligent controller compares the detected speed limit with the current vehicle speed. If the measured speed exceeds the permitted value, the Electronic Control Unit (ECU) automatically regulates the motor drive to reduce vehicle speed smoothly without causing sudden braking. The dashboard simultaneously displays the detected traffic sign, current speed, and updated speed limit, while visual and audio alerts notify the driver about the automatic speed adjustment. The obtained results demonstrate that intelligent speed regulation effectively minimizes overspeeding, improves passenger safety, and ensures continuous compliance with road traffic regulations under different driving conditions.

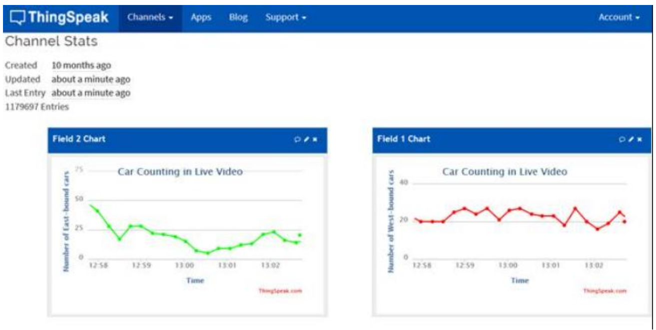

Figure 5. ThingSpeak Cloud Dashboard for Real-Time Road Sign Detection and Vehicle Speed Monitoring

Figure 5 illustrates the ThingSpeak cloud dashboard developed for real-time monitoring of the proposed AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles. During vehicle operation, the Artificial Intelligence model continuously detects road traffic signs using the front-mounted camera and transmits operational information to the ThingSpeak cloud through the ESP32 communication module. The dashboard displays Field 1 (Detected Speed Limit), Field 2 (Current Vehicle Speed), Field 3 (Traffic Sign Detection Count), Field 4 (AI Prediction Confidence), Field 5 (Automatic Speed Control Status), and Field 6 (System Response Time). Whenever a new traffic sign is recognized, the detected speed limit and corresponding vehicle speed are immediately updated on the cloud platform. The automatic speed control status confirms whether the Electronic Control Unit has successfully adjusted the vehicle speed according to the detected traffic regulations. The prediction confidence graph demonstrates stable deep learning performance with consistently high recognition accuracy, while the response time graph indicates rapid processing suitable for real-time autonomous driving. Experimental observations confirmed reliable wireless communication, uninterrupted cloud synchronization, continuous remote monitoring, and accurate visualization of vehicle operating parameters. These results validate the effectiveness of integrating Artificial Intelligence, Computer Vision, ESP32, and ThingSpeak cloud analytics for intelligent traffic sign recognition and autonomous speed regulation in electric vehicles.

VII. CONCLUSION

The proposed AI-Based Road Sign Detection and Automatic Speed Control System for Electric Vehicles successfully demonstrates an intelligent approach for improving road safety through automatic traffic sign recognition and real-time vehicle speed regulation. The developed framework integrates Artificial Intelligence, Computer Vision, Deep Learning, image processing, and an intelligent Electronic Control Unit (ECU) to continuously monitor the driving environment and respond automatically to road traffic signs. A front-mounted camera captures real-time road images, which are processed using a Convolutional Neural Network (CNN) or YOLO-based deep learning model to accurately detect and classify traffic signs such as speed limits, stop signs, pedestrian crossings, school zones, and warning signs. Based on the detected traffic information, the vehicle controller automatically adjusts the motor speed while simultaneously providing visual and audio alerts to the driver. This intelligent decision-making process minimizes dependence on human judgement and significantly reduces the possibility of traffic violations caused by overspeeding or delayed driver response.

Experimental evaluation confirmed that the proposed system achieved reliable traffic sign recognition with high detection accuracy, low response time, and stable speed regulation under different driving conditions. Performance assessment using Accuracy, Precision, Recall, F1-Score, response time, and speed regulation accuracy demonstrated that the Artificial Intelligence model effectively recognized road signs while the automatic control system maintained compliance with traffic regulations. The integration of continuous monitoring, intelligent decision-making, and automatic speed control improved driving safety, reduced driver workload, and enhanced the operational reliability of electric vehicles. The developed framework also demonstrated consistent performance under varying lighting conditions, different road environments, and multiple traffic scenarios.

Overall, the proposed intelligent system provides a reliable, scalable, and cost-effective solution for next-generation electric vehicles and smart transportation systems. By combining Artificial Intelligence, Computer Vision, and automatic vehicle control, the framework enhances road safety, minimizes human driving errors, reduces overspeeding incidents, and improves compliance with traffic regulations. Future work may include the integration of autonomous steering assistance, obstacle detection, lane departure warning, vehicle-to-infrastructure (V2I) communication, edge Artificial Intelligence, and cloud-based traffic analytics to further improve intelligent driving capabilities. The outcomes of this research contribute to the advancement of autonomous electric vehicles and support the development of safer, smarter, and more sustainable intelligent transportation systems.

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