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Traffic Sign Detection Using Deep Learning

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Abstract:

Advanced Driver Assistance Systems (ADAS) are critical for reducing accidents and improving driving performance. This project develops a deep learning-based ADAS using a hybrid model combining YOLOv8 and VGG16 to enhance detection accuracy. YOLOv8 performs real-time object detection, identifying vehicles, pedestrians, and obstacles with high precision, while VGG16 improves lane detection and road sign recognition. This combination strengthens vehicle perception and decision-making capabilities. The system integrates features like obstacle detection, driver monitoring, and adaptive cruise control, processed through a high-performance computing setup. By leveraging deep learning and neural networks, our approach enhances detection accuracy, minimizes false positives, and ensures timely driver assistance. This advancement not only improves driving safety but also brings ADAS closer to the reliability needed for autonomous driving, paving the way for future innovations in the automotive industry.

[1] INTRODUCTION

The ADAS Advanced Driver Assistance Systems plays an important role in improving driving efficiency by increasing road safety reducing accidents and minimizing human errors as demand for intellectual transportation solution increases ADAS based on deep learning is an important direction in automotive research. The project aims to develop a very accurate advertisement by integrating yolov8 and vgg16 using a hybrid model of deep learning. Yolo v8 the condition of the sensing model of the art object increases the accuracy of the actual identification of vehicles pedestrians and road obstacles at the same time. VGG16 a powerful folding network. CNN is improved according to the detection of the lane and the detection of the distance increasing the awareness of the vehicles context the integration of these models increases the perception of the system.

To make decisions increase the possibility of real -time reactions greatly increase the accuracy of identification and minimize false anxiety .The most important features of the proposed ADAS include lane detections that guarantee certain failures and pedestrian vehicles potential collision monitoring fatigue and dismissal decisions adaptive speed control and safe travel paths the system uses high -performance computing resources to handle large amounts of visual data in real time .To provide fast and effective support to the driver this hybrid model combines the strength of the yolov8 speed with the vgg16 feature. Feature extraction function to improve the awareness and safety of the vehicle to make driving more safely and effective.

The proposed ADAS contributes to the advancement of semi-autonomous and autonomous vehicle technologies by providing a reliable foundation for further research and innovation. As deep learning and artificial intelligence continue to evolve, this system paves the way for smarter transportation solutions, ultimately improving road safety and bringing the automotive industry closer to fully autonomous driving. By integrating cutting-edge neural networks and intelligent processing mechanisms, the project not only enhances ADAS reliability but also supports the development of future-ready vehicular technologies, ensuring safer roads for everyone.

1.1. General Introduction

Road safety has become a major concern due to the increasing number of traffic accidents caused by human error. Advanced Driver Assistance Systems (ADAS) have emerged as a key solution to enhance driving safety by reducing accidents and improving vehicle control. These systems leverage artificial intelligence (AI) and deep learning techniques to provide real-time assistance to drivers, ensuring safer and more efficient transportation. The development of ADAS has significantly evolved, incorporating advanced detection models to improve accuracy and reliability in various driving conditions.

This project focuses on creating an ADAS using a hybrid deep learning model that combines YOLOv8 and VGG16. YOLOv8, a state-of-the-art object detection model, is utilized for identifying vehicles, pedestrians, and obstacles with high precision and speed. On the other hand, VGG16, a well-established convolutional neural network (CNN), enhances the system's ability to detect and recognize road signs and lane markings, providing better situational awareness. By integrating these models, the system ensures accurate perception and quick decision-making, reducing the risk of accidents and improving overall driving performance.

The system incorporates essential ADAS functionalities such as lane detection, obstacle and pedestrian recognition, driver monitoring, and adaptive cruise control. High-performance computing resources process visual data in real time, allowing the system to respond promptly to changing road conditions. By leveraging deep learning and neural networks, the hybrid ADAS model enhances detection accuracy, minimizes false positives, and improves overall system reliability.

As automotive technology continues to advance, the proposed ADAS model serves as a step toward the development of smarter and safer transportation solutions. It not only enhances current driver assistance capabilities but also contributes to future innovations in autonomous driving, ultimately leading to safer roads and improved driving experiences for all.

1.3. Problem Statement

The success of advanced driver assistance systems (adas) heavily relies on accurate and real-time detection, but conventional methods frequently fall short in complex driving scenarios. Traditional methods face challenges when it comes to adapting to different lighting conditions, obstructions, and fast-paced situations, resulting in unreliable lane detection, missed obstacles, and delayed decision-making. These restrictions heighten the chances of accidents and decrease the system's overall effectiveness. As the importance of road safety increases, the limitations of current techniques become more apparent, making it necessary to develop a more effective solution. Consequently, there is an urgent requirement for sophisticated deep learning-based models that improve detection accuracy, adaptability, and real-time responsiveness. By combining the use of yolov8 and vgg16, adas can greatly enhance vehicle perception, leading to safer and smarter driving experiences.

1.4. Algorithm

1. VGG16 Model
2. YOLOv8 Model

[2] RELATED WORKS

Yih-chen wang et al., (2022) developed in this study, which is able to remind the drivers to turn on the head lights or wipers through situation recognition method when driving at night or on rainy days. Furthermore, the object detection results from multiple perspective views are integrated, and the surrounding object detection results are produced for collision avoidance. The system is able to alarm the drivers based on the lightweight deep learning model and the distance estimation method when surrounding vehicles are too close. Experimental results show that the proposed methods and the chosen lightweight model in our proposed system obtain reliable performance and sufficient computational efficiency under limited computing resource. In conclude, our proposed system obtains high probability to be adopted for the development of advanced driver assistance systems (ADAS). The proposed system can not only assist the driver in determining the vision ahead, but also provide an instant overview of the vehicles surrounding conditions to enhance driving safety.

Jie et al. (2023) developed a groundbreaking technology in the field of automatic vehicle driving and driver assistance systems. Unfortunately, the current algorithms used for traffic sign recognition encounter difficulties such as large model size, complex computation, high computational cost, which make it challenging to strike a balance between the speed of detection and the accuracy of the results. This paper presented an improved lightweight recognition algorithm, which is derived from yolov5. This algorithm replaces the convolutional structure in the original yolov5 neck network with ghost module and c3ghost module, which helps to reduce redundant features in the feature fusion process, resulting in lower computational cost and the number of parameters.

Sara Khalid et al., (2024) identified that traffic signs have great importance regarding smooth traffic flow and safe driving. However, due to many distractions and capricious factors, spotting and perceiving them may become hazardous. Traffic sign detection and recognition have gained popularity to put an end or to lessen the issue, and massive efforts have been realized in this regard. Despite considerable endeavors put together for traffic sign detection and recognition, there is a lack of attention in this area where these traffic signs contain text in them. A handful of studies may be found in state-of-the-art (SOTA) methods for text-based traffic sign detection, and particularly lesser for text recognition of detected text. The proposed method focuses on developing a robust semi-pipeline intelligent system to detect and understand text from traffic road signs boards in various weather conditions. For this purpose, a customized YOLOv5s is deployed for initial panel detection. Subsequently, MSER with preprocessing techniques issued for localization of text. Finally, OCR with NLP is utilized to recognize the text. The proposed method employed the ASAYAR dataset for training and different datasets for testing. The proposed approach produced satisfactory outcomes on them in contrast with SOTA approaches.

Shouhui et al.,(2021) emphasized the importance of automatic recognition of traffic signs for autonomous driving, assisted driving, and ensuring road safety. Currently, convolutional neural network (cnn) is the most widely used deep learning algorithm in traffic sign recognition. Unfortunately, the cnn is unable to capture the poses, perspectives, and directions of the image, nor accurately identify traffic signs from various viewpoints. To address the issue, the authors proposed an automatic recognition algorithm for traffic signs using visual inspection. To ensure precise visual inspection, a region of interest (roi) extraction method was developed using content analysis and key information recognition. Additionally, a method called histogram of oriented gradients (hog) was created for detecting images to avoid any distortion caused by projection. Additionally, a traffic sign recognition architecture was developed using capsnet, which utilizes neurons to represent various parameters such as dynamic routing, path pose, and direction. This architecture effectively captures traffic sign information from different angles or directions. Finally, our model was compared with several baseline methods using the dataset from the laboratory for intelligent and safe automobiles for traffic sign recognition. The model's performance was evaluated using mean average precision (map), time, memory, floating point operations per second (flops), and the number of parameters. The findings indicate that our model achieved faster recognition times while maintaining superior performance compared to baseline methods, such as cnn, svm, and r-fcn resnet 101.

Shi et al. (2023) developed an algorithm that can extract obscured traffic sign information from road driving images and combine it with the vehicle's movement process by integrating the vehicle's speed. Because the recognition rate of hidden traffic signs is low, the proposed algorithm utilizes a conventional color-shape recognition method to identify potential traffic sign regions. By merging the data from multiple consecutive frames into a single frame, the fusion process enhances the completeness and accuracy of the traffic sign information, making it more comparable to the original characteristics of the traffic sign. The experimental results suggest that integrating traffic sign information from the first and third frames can increase the similarity of the template matching by 15.2%. And successfully identifies traffic signs that cannot be recognized by the yolov4 and yolov8 convolutional neural network when driving at speeds of 18(km/h), 36(km/h), and 54(km/h). The findings highlight that the proposed algorithm can effectively merge obscured traffic sign data while a vehicle is in motion, leading to traffic signs that exhibit more similar geometric attributes to the original signs.

Davor Sluga and his colleagues, in their 2020 study, highlighted the current focus of autonomous vehicle development on the real-time processing of large volumes of data obtained from multiple sensors. The data can be obtained through various sensors, including cameras, lidars, ultrasonic sensors, and radars, which provide valuable insights into the traffic conditions and the environment. The ability to process data quickly is crucial for the effective functioning of vehicles that not only assist the driver but can also operate autonomously. This article suggests enhancing the speed and accuracy of traffic sign detection and recognition in high-definition images by focusing on specific regions of interest within the images. These areas are identified using efficient and parallelized preprocessing of every traffic image, followed by the application of a convolutional neural network for detection and recognition on graphics processing units. We utilized various you only look once (yolo) architectures as baseline detectors, as they are known for their speed, simple design, and high accuracy in general object detection tasks. Various preprocessing techniques were suggested to meet the real-time performance requirement. Our experiments with a vast collection of traffic signs demonstrate that we can achieve real-time detection in high-definition images with a high level of accuracy.

3. EXISTING METHODOLOGY

Advanced Driver Assistance Systems (ADAS) enhance traffic safety by using sensors like radar, lidar, and cameras to detect and respond to driving conditions. Due to the high cost and complexity of depth sensors, many ADAS rely on camera-based solutions with deep learning models for real-time object detection. Traditional methods like Haar features and HOG have evolved into deep learning techniques such as RCNN, Fast RCNN, and YOLO, improving accuracy but often requiring high computational power. Lightweight models like MobileNetV2 optimize performance while maintaining efficiency, aiding collision prevention through 3D spatial awareness. Challenges remain in making ADAS fully autonomous, requiring improvements in detection accuracy, 3D perception, and real-time processing. Future advancements will focus on integrating multiple data sources and enhancing situational awareness for safer, more intelligent driving.

3.1. DISADVANTAGES

The high demand for computing power in embedded systems can put a strain on their performance, restricting their capabilities. The expensive nature of depth sensors like lidar limits their application in consumer vehicles, leading to the prevalence of camera-based solutions. Nevertheless, the accuracy of camera-based detection can be influenced by unfavorable weather conditions. Furthermore, intricate algorithms might impede processing speed, which could disrupt real-time driver assistance.

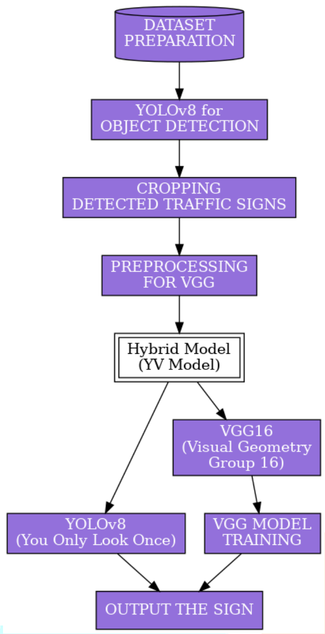
4. PROPOSED METHODOLOGY

A hybrid model that combines vgg16 and yolov8 is developed for traffic sign detection, integrating deep feature extraction with real-time object detection to enhance accuracy and efficiency. Vgg16 enhances the representation of features, resulting in improved classification accuracy, while yolov8 ensures quick and precise localization of traffic signs in various surroundings. The model is trained on a diverse dataset to enhance its capability to handle different lighting and weather scenarios. By employing cutting-edge deep learning techniques, the system effectively balances computational efficiency and detection accuracy. Having the ability to identify multiple traffic signs simultaneously increases the practicality of this skill in real-life scenarios. Robust performance is achieved even in challenging situations such as occlusions and varying lighting conditions. By integrating vgg16, the feature extraction process becomes more precise, enabling more accurate recognition of intricate sign patterns. Yolov8's lightning-quick processing capabilities make it perfect for real-time applications, like self-driving cars and advanced transportation systems. The system improves navigation safety and reliability by ensuring accurate recognition in dynamic road conditions. The precision of detection enhances the decision-making process for automated driving systems.

4.1. ADVANTAGES

The model exhibits remarkable precision in identifying various types of traffic signs, facilitating instant detection. Its advanced features help minimize human error, significantly enhancing traffic safety. The system is designed to be highly scalable, enabling it to be effortlessly modified to handle different datasets and adapt to various environments. By striking the perfect balance between precision and efficiency, it optimizes performance for intelligent transportation systems. By adopting this method, we can guarantee precise identification of traffic signs, which ultimately improves road safety and the effectiveness of our transportation networks.

4.2. BLOCK DIAGRAM



5. RESULTS

5.1.ACCURACY

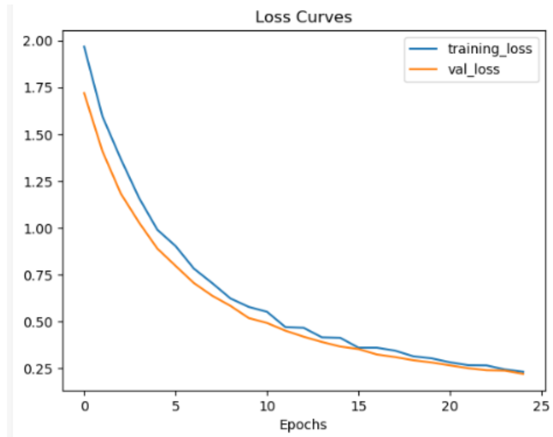
The overall accuracy of the model is 92%. Class 5 has the lowest performance, with a precision of 0.50 and recall of 1.00, indicating many false positives. The macro average (unweighted mean) of F1-scores is 0.91, showing that the model performs well across most classes. The weighted average (takes class frequency into account) is 0.92, which closely matches the accuracy, indicating a balanced dataset. This report suggests that the model performs well overall but may need improvements for certain classes, particularly class 5.

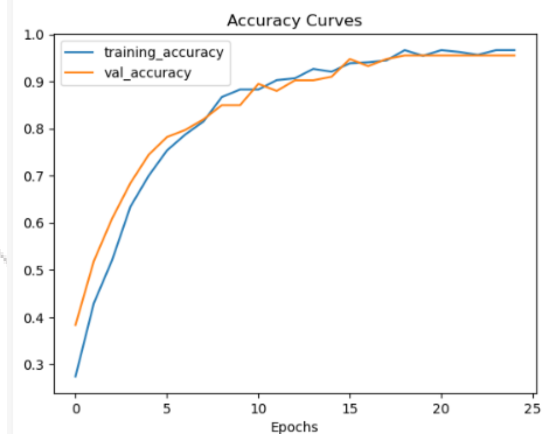
```
1/1 [==============================] - 3s 3s/step
              precision    recall  f1-score   support

           0       1.00      1.00      1.00         7
           1       0.75      0.86      0.80         7
           2       1.00      1.00      1.00         8
           3       1.00      1.00      1.00         4
           4       1.00      0.78      0.88         9
           5       0.50      1.00      0.67         1
           6       1.00      1.00      1.00         2

    accuracy                           0.92        38
   macro avg       0.89      0.95      0.91        38
weighted avg       0.94      0.92      0.92        38
```

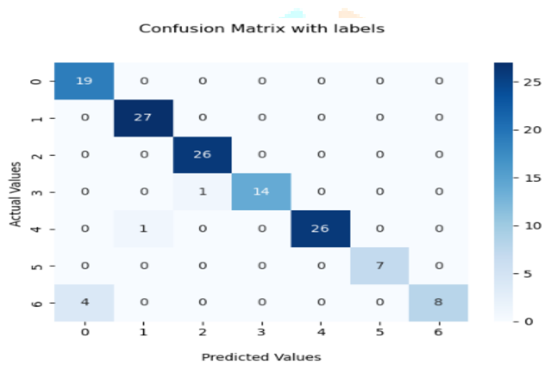
5.2. LOSS CURVE AND ACCURACY CURVE





The training and validation loss and accuracy over 25 epochs, and the results are encouraging. The loss curves consistently declined as the training progressed, suggesting that the model was improving and approaching an optimal solution. Simultaneously, the accuracy curves displayed a steady upward progression, with both the training and validation accuracy remaining relatively close to one another. This is a positive indication because it implies that the model is not overfitting — it is effectively generalizing to data it has not encountered previously. Overall, the model appears to perform well on the test data.

5.3. CONFUSION MATRIX



Confusion matrix representing the performance of a classification model. Most predictions tend to be accurate, with high values along the diagonal, suggesting strong model performance. Occasionally, mistakes happen, and class 6 is often mistaken for class 0. Overall, the model is effective but could benefit from enhancements for specific classes.

6. CONCLUSION

The integration of YOLOv8 and VGG16 in an Advanced Driver Assistance System (ADAS) significantly enhances vehicle perception and decision-making capabilities. By combining YOLOv8's real-time object detection with VGG16's superior lane detection and road sign recognition, our system effectively overcomes the limitations of traditional ADAS models. This hybrid approach ensures more accurate detection of vehicles, pedestrians, and obstacles while improving adaptability to varying lighting conditions and complex driving scenarios. As a result, the system reduces missed detections and false positives, enhancing overall road safety.

Additionally, the inclusion of key features such as driver monitoring, and adaptive cruise control further strengthens the reliability of the proposed ADAS. The high-performance computing setup enables efficient data processing, ensuring real-time responsiveness and timely driver assistance. These advancements not only minimize accident risks but also contribute to a more intelligent and proactive driving experience, making ADAS more practical for real-world applications.

Ultimately, this research brings ADAS closer to the reliability required for autonomous driving, paving the way for future innovations in the automotive industry. By leveraging deep learning techniques, the proposed system sets a foundation for smarter and safer driving solutions. As technology continues to evolve, the integration of advanced AI models in ADAS will play a crucial role in shaping the future of transportation, ensuring enhanced safety, efficiency, and overall driving performance.

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