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Real-Time Vehicle Detection and Classification in Traffic Videos Using Yolov8

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Abstract
The Vehicle detection is important for the enhancement of transportation systems and which is efficient for traffic management, improved road safety and accurate data collection by automatically identifying and tracking vehicles on roads which enables features like traffic signal optimization, speed measurement and accident detection ultimately contributing to a smoother and safer driving experience for everyone. Here we have built a real-time project which can detect car, bus, motorcycle and truck on the basis of algorithm called YOLOV8 (You Only Look Once Version 8). It is a computer vision technique which is renowned for its real-time object detection capabilities, providing optimal balance between speed and accuracy. The model is trained using PyTorch and leverages Convolutional Neural Network (CNN) for feature extraction.
Keywords: *Vehicle detection, Convolutional Neural Network, YOLOV8, PyTorch, Ultralytics, Deep Learning, Python, Feature Extraction, Image Detection*

1. Introduction

As technology is being advanced, Artificial Intelligence and machine learning are becoming one of the essential components in one's own life. As rapid increase in vehicles on the road has created many challenges in traffic management. The main motto or aim of this real-time project is to reduce the damages causing on roads. Like, to ensure safe and smooth handling of traffic signals, to control speed of a vehicle and mainly to overcome the accidents by predicting it before.[1-2] Vehicle Detection is a crucial application in computer vision, with wide ranging uses in traffic monitoring, autonomous driving, security and environmental management. Though we have these many uses, we still consider them as factors. YOLOV8 a computer vision methodology, which stands for You Only Look Once which is mainly used for object detection which has been a high performance model in detecting and classifying the objects in images and videos. Implementing these methodologies is not at all a difficult task, but handling different factors like lighting, environmental challenges, and human errors is essential. YOLO is known for its balance between detection, speed and accuracy. The algorithm identifies objects by dividing an image into a grid and predicting bounding boxes and class probabilities for each grid cell. Each bounding box is associated with a confidence score that indicates the probability that the bounding box contains an object. The algorithm also predicts a class probability for each bounding box, providing categorical classification of the detected object. Our project can identify wide varieties of objects like car, bus, motorcycle and truck in real-time. This provides a crucial environmental information for the autonomous driving system, allowing it to make informed decisions and react appropriately to its surroundings. This research aims to contribute to the development of safer and more efficient autonomous driving systems by providing a robust and reliable vehicle detection mechanism. The findings of tresearch can significantly aid in the development of smart cities and contribute to the

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broader field of artificial intelligence in transportation. [3]

2. Literature Review

Before advancement in artificial intelligence many researchers have tried to build a vehicle detection system using several traditional approaches like as mentioned below. Traditionally, methods like the histogram of oriented gradients (HOG) have been used to implement vehicle detection. These traditional approaches often involve complex workflows, significant manual intervention, and lengthy processing times. To overcome these challenges, convolutional neural networks (CNNs) have been introduced, demonstrating superior performance. Further advancements in this field have led to the development of region-based convolutional networks (R-CNN), Fast R-CNN, Faster R-CNN, and region-based fully convolutional networks (R-FCN), which employ a two-stage detection process. This process begins with the generation of region proposals and is followed by their refinement through localization and classification [1] Initially, convolutional algorithms focused on background removal and feature extraction defined by users, but these faced difficulties with dynamic backgrounds and variable weather conditions [2] Another strategy Tuermer et al. (2013) involved a Heavy Traffic-Aware HOG (HTA-HOG) based on areas with heavy traffic. Hybrid DNN techniques were utilized by the author [10] The success of YOLO in the previous version was applied in many fields, so that many developers and the community were very interested in trying the latest technology and the results were sure to be faster and more accurate than the previous version. YOLOv8 introduces new features and enhancements to further increase performance and flexibility. YOLOv8 is designed to be fast, accurate, and easy to use, making it an excellent choice for a wide variety of object detection and tracking, instance segmentation, image classification, and pose estimation tasks. [8] Corovi´c, Ili´c et al. proposed YOLOv3, which was ´ trained for five classes, including cars, trucks, street signs, people, and traffic lights. It was proposed to detect traffic participants effectively across various weather conditions [1] YOLOv10, although faster in post-processing due to its non-maximum suppression (NMS) free approach, which reduces latency, tends to miss smaller objects because of fewer parameters and lower confidence scores [1] These trials lead to evolution of autonomous vehicle detection with the help of Deep learning mechanisms. The integration of computer vision and convolutional neural networks made the model more efficient and optimum. Though we have YOLOV10 we choose YOLO Version 8 to build the model as we can see the consistency and accuracy of that version. YOLOV10 works faster than Version 8 but with its non- maximum suppression it went down.

3. Proposed System

The Real-Time Vehicle Detection and Classification in Traffic Videos Using YOLOv8 is designed to automatically identify and categorize different types of vehicles in traffic footage using advanced object detection techniques. The system processes video frames from either a webcam or pre-recorded videos and employs the YOLOv8 model to detect vehicles such as buses, cars, motorcycles, and trucks with high accuracy and speed. This approach enhances traffic monitoring, management, and data analysis, reducing the need for manual observation. The system operates through a structured pipeline, including video capture, frame preprocessing, model inference, and real-time visualization of detection results. The YOLOv8 model, trained on vehicle datasets, identifies objects in each frame, drawing bounding boxes around detected vehicles along with class labels and confidence scores. The detected information is displayed on the video feed, enabling efficient monitoring of vehicle flow. This robust system is applicable in intelligent transportation systems, traffic surveillance, and smart city applications, offering real- time, reliable vehicle detection and classification. [4]

4. System Implementation

4.1. Data Collection and Pre-Processing

The first step involves collecting the dataset of images and videos that contain various types of vehicles under different driving conditions. The images and videos are pre-processed to ensure they are suitable for input into the YOLOV8 model. This includes resizing the images and videos to the required dimensions, normalizing the pixel values,

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and augmenting the data to increase its size and diversity. [5]

4.2. Model Training

The model is trained on the pre-process dataset. We train model to detect and classify different types of vehicles. The training process involves feeding the images and videos into the model, which then predicts bounding boxes and class probabilities for each object in the images and videos. The model's predictions are compared to the ground truth labels, and the model's parameters are updated to minimize the difference between the predictions and the ground truth labels. This process is repeated for several epochs until the model's performance on the validation set stops improving. [6]

4.3. Object Tracking

After the model is trained, it is used to detect and classify vehicles in real-time. The model predicts bounding boxes and class probabilities for each object in the images and videos, and these predictions are used to track the vehicles. [7]

4.4. Evaluation

The model is evaluated after training and testing. It is evaluated using various metrics such as precision, recall and the mean average precision. These metrics provide a quantitative measure of the model's ability to detect and classify vehicles accurately and efficiently. The model's performance is also tested under different driving conditions to ensure its robustness.

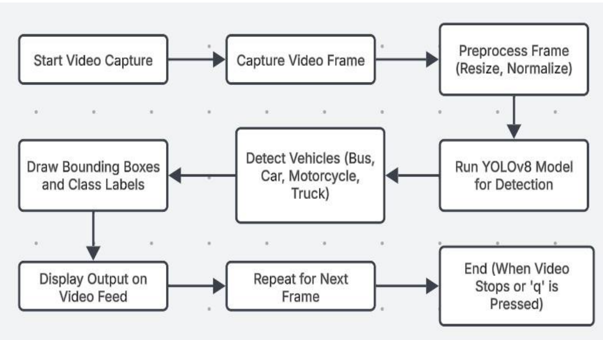

Figure 1 Functional Workflow

4.5. Optimization

Based on the models evaluation results, model's patameters are fine-tuned to improve its performance. This involves adjusting hyperparameters, such as the learning rate and the number of epochs and using techniques such as early stopping and dropout to prevent overfitting. (Figure 2) [8]

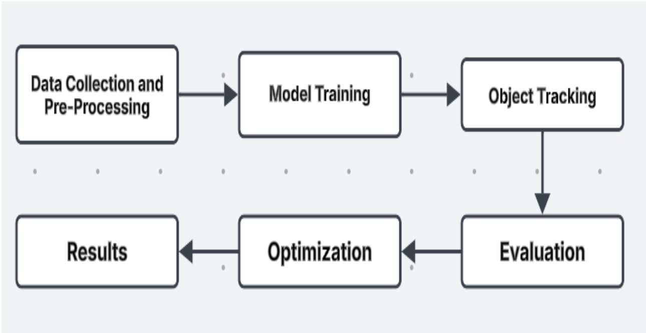

Figure 2 System Implementation

5. Results

The model was tested on a video featuring moving cars in a traffic environment. During the testing, the YOLOv8 model performed real-time object detection with high accuracy. As the video played, the model was able to quickly identify each vehicle, regardless of its speed or position within the frame. Each detected vehicle was highlighted with a clear bounding box, making it easy to distinguish from the background. Alongside these boxes, the model displayed labels indicating the type of vehicle such as "Car," "Bus," "Truck," or "Motorcycle" along with a confidence score that reflects how certain the model is about its prediction. The detection process was smooth and responsive, effectively recognizing vehicles even in complex scenes with overlapping objects or varying lighting conditions.This demonstrates the model's robustness and reliability for real-world applications like traffic monitoring, surveillance, and intelligent transportation systems. The detection process was smooth and responsive, effectively recognizing vehicles even in complex scenes with overlapping objects or varying lighting conditions. This demonstrates the model's robustness and reliability for real-world applications like traffic monitoring, surveillance, and intelligent transportation systems. In addition to accurately identifying vehicles, the model showed impressive performance in handling different challenges such as varying vehicle sizes,

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fast motion, and partial occlusions where one vehicle might block another. (Figure 3)

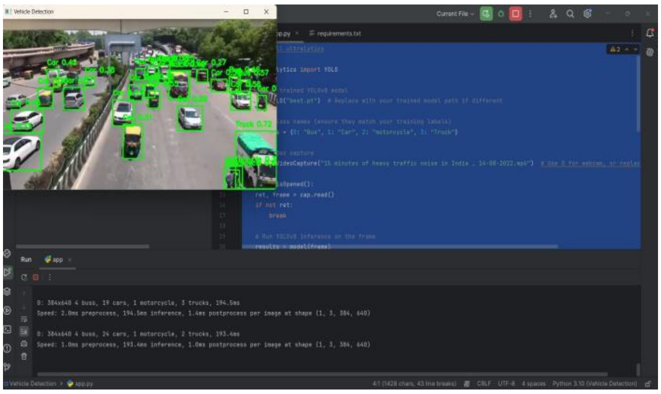
Figure 3 **Detecting and Labelling the Vehicles**

Even in crowded traffic situations, the model could differentiate between vehicles of different categories without confusion. The bounding boxes adjusted dynamically as the vehicles moved, maintaining precise tracking throughout the video. Furthermore, the model's real-time capability ensures there is no noticeable delay between the vehicle appearing on the screen and its detection. This makes it suitable for live traffic surveillance, where quick response times are critical. The confidence scores helped in understanding the model's certainty, with most detections scoring above 90%, indicating strong reliability. Overall, the YOLOv8-based vehicle recognition system not only detects vehicles with high accuracy but also adapts well to real-world conditions, making it an effective solution for automated traffic analysis and enhancing road safety through intelligent monitoring. [9]

Conclusion

Finally, I conclude that, our research highlights the considerable potential of YOLOv8 as a valuable tool for vehicle detection in autonomous vehicles. Its outstanding performance, characterized by high accuracy, precision, and recall, underscores its ability to identify vehicles accurately and minimize false positives and negatives. Additionally, the balanced F1-score and commendable mean average precision (mAP) demonstrate its competence in object localization and classification, crucial for ensuring safety in complex road environments. Comparative analysis further establishes YOLOv8 as a leader not only in accuracy but also in real-time performance. Its accuracy and computational efficiency make it ideal for real-time applications, especially in the high-stakes context of autonomous vehicles. However, challenges persist, including addressing complex intersections and improving the detection of pedestrians and cyclists. Deployment considerations encompass hardware, safety, and scalability for diverse vehicle types. In anticipation of the autonomous transportation era, YOLOv8 emerges as a powerful tool, paving the way for safer, more efficient, and accessible transportation solutions. This research significantly contributes to the expanding knowledge of autonomous driving, bringing us closer to realizing a transformative vision for safer and more convenient transportation systems.

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