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Vehicle Detection Using Haar Cascade Algorithm

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ABSTRACT

Deep Learning is a rapidly advancing field that has the power to completely transform a lot of different industries and fields of study. One critical task within this domain is vehicle detection, which has practical applications in domains such as traffic management, public safety, and autonomous driving. Intelligent Transportation Systems (ITS) can be used for vehicle detection to count and track vehicles, detect incidents, and collect tolls. This helps improve traffic management, monitor flow and congestion, and better meet the needs of travellers and commuters, making transportation systems safer, more efficient, and effective. The goal of this task is to develop algorithms that, after being trained, can recognize, and locate automobiles automatically in pictures or videos Deep Learning models on labelled datasets of vehicle examples. Another related activity that utilizes deep learning is object detection is Finding and locating items in pictures or movies. This task aims to automatically detect and classify objects within a scene and determine their precise location. Object detection using Deep Learning is beneficial in real-time applications such as surveillance systems, robotics, and self-driving cars, and can result in improved safety, efficiency, and automation across various domains.

Keywords : Computer vision, Intelligent transport system (ITS), Vehicle detection, Traffic management.

I. INTRODUCTION

Vehicles have become an essential part of modern society, with significant impacts on our daily lives and the global economy so that increase of vehicle in world has huge amount. It provides a convenient effective mode of transportation, allowing individuals to go to their places of employment, education, and other destinations[4,5]. They are also essential for transporting goods and materials, supporting trade and business. The automotive sector employs millions of people and is a major employer people on the planet[6]. This covers not just sales and manufacturing but also research and all. As Vehicles are a critical component of transportation infrastructure, requiring the construction and maintenance of roads, highways, bridges, and tunnels. This infrastructure supports economic growth and development and facilitates movement and connectivity between regions and countries[7,8,9]. The development of vehicles has driven technological developments in several disciplines, such as engineering, materials science, and software engineering[10]. Recent developments in autonomous and electric car technology could reshape transportation while minimizing negative environmental effects. According to estimates, by 2050, there will be over ten billion automobiles are driven worldwide. While transportation may generate threats such as road accidents, traffic on road. To reduce accident on road the Intelligent Transportation System is evolved. Deep Learning is employed to lessen this problem by detecting vehicle[11,12]. Through Deep Learning advanced warning, detecting hazards in real-time, and optimizing traffic flow.

II. Problem Statement:

The challenges associated with vehicle detection include the need for accurate identification and localization of vehicles amidst complex backgrounds, occlusions, and variations in lighting conditions. Furthermore, the system must be capable of handling real- time video streams, ensuring fast and efficient processing to meet the requirements of surveillance, traffic monitoring, and autonomous driving applications. The proposed solution aims to leverage the Haar Cascade algorithm's ability to utilize Haar-like features and machine learning techniques to train a classifier on a dataset of positive and negative samples. By extracting relevant features and employing a trained classifier, the system can effectively distinguish vehicles from the background and accurately detect their presence in real-time video streams. By addressing the challenges related to lighting conditions, occlusions, and complex backgrounds, the proposed system aims to provide reliable and efficient vehicle detection capabilities for a wide range of applications, including surveillance, traffic management, and autonomous driving.

III. Literature Survey

‘Single Shot Multi-Box Detector (SSD)’ by Wei Liu et al. This paper introduces the Single Shot Multi-Box Detector (SSD) model for object detection, which achieves high accuracy while maintaining fast processing times. The authors demonstrate the effectiveness of the model on vehicle detection on highways and in urban area environments. ‘Vehicle Detection and Tracking with Deep Learning’ by Wenjie Wang et al. This study describes a system for identifying vehicles and tracking using a deep learning model. The authors illustrate the system's efficacy in actual real-world traffic data and show that it outperforms conventional methods in computer vision. Accelerated R- CNN: Moving Towards Real-Time Object Recognition with Networks for Region Proposal by Shaoqing Ren et al. This paper presents a faster R-CNN model for object detection, which uses a region proposal network to identify potential object locations before detecting objects with precision. The model's efficacy in vehicle detection is exhibited by the authors across multiple scenarios. "YOLO: Instantaneous Object Recognition" by Redmon Joseph et al. The YOLO (You Only Look Once) deep learning architecture is proposed in this paper for real-time object detection, including car detection. The model is appropriate for real-world applications because it achieves high accuracy and quick processing times. Du Tran et al.'s "Deep Convolutional Neural Networks for Efficient Vehicle Detection" A deep convolutional neural network architecture is suggested in this paper for effective vehicle detection. Using a large-scale dataset, the authors show the model's efficacy and show that it can achieve high accuracy with quick processing times.

1. A Real-Time YOLO and Centroid Tracking-Based Wrong-Way Vehicle Detection System The study suggests a real-time centroid tracking and YOLO-based wrong-way vehicle detection system. It combines the effectiveness of centroid tracking for real-time tracking with the precision of YOLO for initial vehicle detection. In order to prevent accidents, the system attempts to identify vehicles that are traveling in the incorrect direction. Through the utilization of centroid tracking to track object positions and YOLO's object detection capabilities, the

suggested system offers a practical way to detect vehicles traveling the incorrect way in real time. Because this work allows for early detection and timely alerts for incidents involving drivers going the wrong way, it has the potential to improve road safety.

2. A Provident Vehicle Detection at Night Dataset. In this paper, a dataset created especially for nighttime provident vehicle detection is presented. The purpose of the dataset is to address the difficulties posed by low light levels and the requirement for precise vehicle detection in such situations. It includes an extensive set of annotated photos taken in a variety of nighttime settings, such as cities, countryside, and highways. The purpose of the dataset is to support research and development of robust and dependable algorithms for vehicle detection in low-light situations. This work advances computer vision systems that can detect vehicles in difficult lowlight conditions by offering a benchmark dataset, thereby increasing safety and security in nocturnal driving scenarios.

3. Transformer-Based End-to-End Object Detection [3] The method for end-to-end object detection in the paper makes use of transformers, a kind of neural network architecture that was first created for tasks involving natural language processing. The authors suggest a brand-new object detection model called DETR (DEtection TRansformer), which does away with the requirement for intricately crafted manual parts like non-maximum suppression and anchor boxes. Using self-attention mechanisms, DETR obtains the set of object detections directly from the sequence prediction problem, capturing global dependencies in the image. The model offers simplicity, flexibility, and increased runtime efficiency while achieving competitive results on object detection benchmarks. The study demonstrates how transformers have the potential to completely transform object detection and computer vision applications.

4. Scalable and Effective Object Detection with EfficientDet. A scalable and effective object detection framework called EfficientDet is presented in this paper. The authors suggest a compound scaling technique that increases the detection network's accuracy and efficiency by uniformly scaling all its dimensions. Additionally, they present a brand-new EfficientNet backbone that better balances depth and width for improved accuracy and computational efficiency trade-offs. EfficientDet is much faster than previous methods and achieves state-of-the-art performance on multiple object detection benchmarks by combining the scaling method with the EfficientNet backbone. The study highlights how crucial it is to strike a balance between computational efficiency and model complexity to provide scalable and effective object detection solutions.

5. For instance segmentation, a powerful data augmentation technique is simple copy-paste. For instance, segmentation tasks, the paper presents a straightforward yet efficient data augmentation technique called Simple Copy-Paste. It creates new training examples by utilizing the concept of copying and pasting objects from one image to another. The authors show that by using this method, instance segmentation models perform better than ever, even outperforming more intricate and costly augmentation techniques. Benefits of Simple Copy-Paste include better generalization to real-world scenarios, preservation of object-level annotations, and avoidance of the need for additional labeling work. The study demonstrates how this simple data augmentation method can improve instance segmentation tasks' robustness and performance.

Paper Title	Algorithm	Year	Journal	Work
A Real-Time Wrong-Way Vehicle Detection Based on YOLO and Centroid Tracking [1]	YOLO (You Only Look Once)	2022	The proposed system for vehicle detection and tracking in videos involves two stages. First, the YOLO object detector is used to detect every vehicle in the frame, as it is a highly accurate and efficient algorithm. The resulting bounding boxes are then passed to a centroid-based tracking algorithm, which tracks each vehicle in the specified region of interest. By computing the centroid height of each vehicle in consecutive frames, the system can determine the direction of vehicles.	Developed a machine learning model to predict early-stage Alzheimer's disease using MRI data. The model achieved an accuracy of 95.2% on a held-out test set.
A Dataset for Provident Vehicle Detection at Night [2]	SOTA (State-Of-The-Art)	2021	It presents a new dataset of nighttime driving scenes with annotated vehicle detections, which is an important contribution to the field of computer vision for autonomous driving. The authors evaluate different state-of-the-art vehicle detection algorithms on the dataset and provide insights into the limitations of current approaches for nighttime vehicle detection. This work can be useful for developing more accurate and reliable systems for nighttime driving scenarios.	The authors evaluate several state-of-the-art vehicle detection algorithms on this dataset and highlight the limitations of current approaches for nighttime vehicle detection. This research provides valuable insights into the challenges of developing accurate and reliable systems for nighttime driving scenarios, which can inform the development of future approaches in this area.

Resilience of Autonomous Vehicle Object Category Detection to Universal Adversarial Perturbations [3]	Faster-RCNN	2021	Through meticulous experimentation, we created a diverse and realistic COCO dataset and separated the failure of object detection into two categories: failure with and without perturbations. This is an important finding, as perturbations that are imperceptible to humans can still cause significant harm in an adversarial attack.	The scope of the paper is limited to universal adversarial perturbations and does not examine other types of attacks. The experiments are constrained to a particular object detection model and dataset, and it is uncertain whether the findings will apply to different models or datasets. Moreover, the paper assumes a flawless detection model and does not account for the effect of incorrect detections on the system's robustness.

Table 1. Literature Survey

IV. Objective

The objectives of this research project are as follows:

1. Develop a vehicle detection system based on the Haar Cascade algorithm that can accurately and efficiently identify vehicles in real-time video streams.
2. Pre-process input images to enhance their quality, including image resizing, grayscale conversion, and histogram equalization, to improve the performance of the vehicle detection system.
3. Train a Haar Cascade classifier using a large dataset of positive and negative samples to enable the system to accurately distinguish vehicles from the background.
4. Evaluate the performance of the developed system using a dataset of actual traffic videos, measuring its accuracy rates and real-time processing capabilities.
5. Address challenges related to lighting variations, occlusions, and complex backgrounds to improve the robustness and reliability of the vehicle detection system.
6. Compare the performance of the Haar Cascade algorithm with other popular supervised learning algorithms, such as the Histogram of Oriented Gradients (HOG) algorithm and Convolutional Neural Networks (CNN), to assess the effectiveness of the proposed system.
7. Validate the proposed system's effectiveness for real-world vehicle detection applications, demonstrating its potential impact in domains such as surveillance, traffic monitoring, and autonomous driving.

By achieving these objectives, the research aims to contribute to the development of an accurate, efficient, and real-time vehicle detection system using the Haar Cascade algorithm, with potential applications in various domains requiring vehicle identification and monitoring.

V. Software System Architecture

Overall, the system architecture for vehicle detection using Haar Cascade algorithm typically comprises several interconnected components:

1. Data Source:

The system acquires input data, such as a video stream or images, from a camera or other sources.

2. Preprocessing Module:

The preprocessing module performs data preprocessing tasks such as resizing, normalization, and grayscale conversion to prepare the input data for feature extraction.

3. Feature Extraction Module:

The feature extraction module uses the Haar Cascade algorithm to extract features such as edges and shapes from the preprocessed data.

4. Classification Module:

The classification module applies a machine learning algorithm, such as HCC, to classify the extracted features as either vehicles or non-vehicles.

5. Post-Processing Module:

The post-processing module applies techniques such as non-maximum suppression to remove false positives and enhance the detection accuracy.

6. Visualization Module:

The visualization module displays the results, such as bounding boxes around the detected vehicles, to provide feedback to the user.

7. Deployment Platform:

The deployment platform runs the system in a suitable environment, such as a traffic intersection or parking lot, to perform vehicle detection in real-time.

The system architecture for vehicle detection using Haar Cascade algorithm should be scalable and modular, with well-defined interfaces between the components. Moreover, the system architecture should incorporate fault-tolerant mechanisms and error handling techniques to ensure reliable performance in real-world scenarios. the diagnostic process, and ultimately improve access to quality healthcare.

VI. Methodology and Discussion

To address the problem of vehicle detection in real-time video streams, several methodologies will be employed throughout the project. The methodologies encompass the following steps:

1. Literature Review: Conduct an extensive review of relevant literature to gain a comprehensive understanding of existing approaches, algorithms, and techniques for vehicle detection using the Haar Cascade algorithm. This review will serve as a foundation for developing the proposed system.
2. Data Collection: Gather a diverse dataset of positive and negative samples containing images and videos of vehicles and non-vehicles. The dataset should encompass various vehicle types, lighting conditions, and backgrounds to ensure a robust and representative training set.
3. Data Pre-processing: Apply pre-processing techniques to enhance the quality of input images. This includes image resizing, grayscale conversion, and histogram equalization to improve the system's performance by standardizing the input data.
4. Haar Cascade Training: Utilize the collected dataset to train a Haar Cascade classifier. Extract Haar-like features from the training samples and employ machine learning techniques to train the classifier to accurately identify vehicles.
5. System Development: Develop the vehicle detection system using the trained Haar Cascade classifier. Implement the necessary algorithms and techniques to process real-time video streams, applying the classifier to identify vehicles in each frame.
6. System Evaluation: Evaluate the performance of the developed system using a dataset of actual

traffic videos. Measure accuracy rates, detection speed, and the system's ability to handle different environmental and lighting conditions.

7. Performance Optimization: Fine-tune the system parameters and algorithms to improve accuracy, speed, and robustness. Address limitations and challenges encountered during evaluation, such as handling occlusions and complex backgrounds.
8. Comparative Analysis: Conduct a comparative analysis of the proposed Haar Cascade algorithm with other popular supervised learning algorithms, such as the Histogram of Oriented Gradients (HOG) algorithm and Convolutional Neural Networks (CNN). Compare their effectiveness in vehicle detection tasks.
9. Documentation and Reporting: Document the methodologies, experimental setup, and findings of the project in a structured manner, adhering to the guidelines and requirements of the black book format. Present the results and conclusions drawn from the evaluation and analysis.

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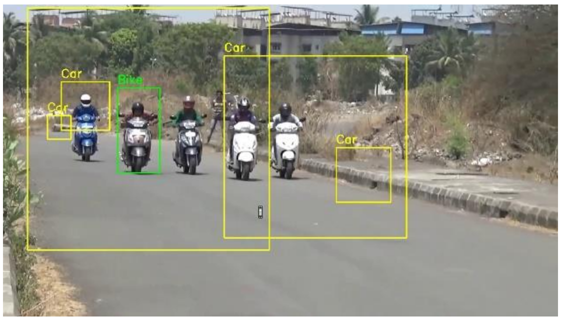
VI. Result and Analyses

We used Haar cascade algorithm with and without Hyperparameter tunning. Hyperparameter increases the accuracy of result giving us a better output.

Results using normal Haar cascade algorithm:



Results using Haar cascade with Hyperparameter tunning:

VII. Conclusion

In conclusion, the Haar Cascade algorithm is a powerful method for vehicle detection that utilizes mathematical models and machine learning algorithms. The algorithm extracts feature from the input data, classifies these features, and applies post-processing techniques to enhance the accuracy of the detection. Models such as the data flow model, entity relationship model, and UML diagrams help in comprehending the system's components, interactions, and relationships, thereby assisting in its development.

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