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Real Time Vehicle Counting and Classification at Traffic Signals

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Abstract: *This project presents a deep learning-based system designed to analyze traffic videos by detecting, classifying, and counting different types of vehicles. The system works in two steps. First, a Convolutional Neural Network (CNN) is trained on a custom car image dataset to recognize specific vehicle models like Swift, Scorpio, and Innova. The dataset used for training was downloaded from Kaggle, a popular open-source data platform. In the second step, the YOLOv8 object detection model is used to find and mark vehicles in each frame of a traffic video. Each detected vehicle is cropped from the frame and passed to the CNN model to identify its exact type. For testing and demonstration, a sample traffic video was obtained from Pexels, a free stock video website. This combined approach offers reliable vehicle detection and classification, and helps collect valuable information from traffic footage that can support further analysis and monitoring. The system achieved an overall accuracy of 85%, showing that it performs well for traffic video analysis and vehicle classification tasks*

Keywords: CNN, YOLOv8, Vehicle Detection, Deep Classification, Traffic Surveillance, Object Recognition.

I. INTRODUCTION

This research presents a deep learning-based system designed to automatically detect, classify, and count vehicles from traffic video footage. The solution uses a two-stage approach: in the first stage, a Convolutional Neural Network (CNN) is applied to recognize the make and model of vehicles, such as Swift, Innova, and Audi. In the second stage, the YOLOv8 object detection model is used to detect and locate vehicles in each frame of the input video in real time [1]. The system is designed to work with pre-recorded traffic videos, which are collected from publicly available sources such as Kaggle. Its main objective is to automate important vehicle-related tasks like detecting, classifying, and counting vehicles. By doing so, the system helps in analyzing traffic patterns, enhancing road safety measures, and supporting the planning and management of transport systems [2].

Convolutional Neural Network (CNN) Architecture:

Convolutional Neural Networks (CNNs) are a type of deep learning model that are especially good at handling image-related tasks. They can learn patterns and features from images on their own, without needing manual programming.The CNN architecture used in this project includes the following essential components:

- **Convolutional Layers:** These layers scan input images using filters to detect basic patterns like edges, textures, or shapes [3].
- **ReLU Activation Function:** This introduces non-linearity to the model by replacing negative values with zero, helping it learn complex features.

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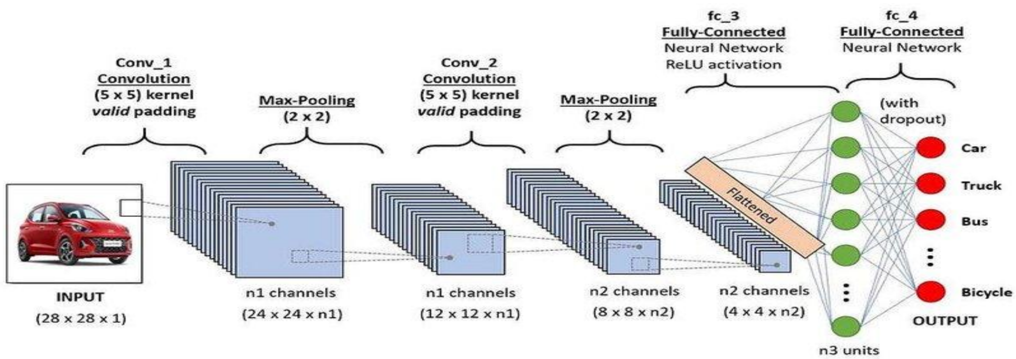
- **Pooling Layers:** Pooling layers help simplify the feature maps by reducing their size, which speeds up processing and lowers the computational load. At the same time, they keep the most important features intact, ensuring the model still learns effectively.
- **Fully Connected (Dense) Layers:** These layers interpret the features extracted by earlier layers and output the final prediction (e.g., car_Swift).
- ***Dropout Layer:*** Dropout is a regularization technique where certain neurons in the network are temporarily turned off during training. This helps the model avoid relying too heavily on specific features and improves its performance on new, unseen data [4].



FigNo:1.1 Architecture of Convolutional Neural Networks.

YOLOv8 Architecture:

YOLOv8 is the most recent advancement in the YOLO series of models developed for object detection.. It offers a powerful combination of high accuracy and fast inference speed, making it ideal for real-time applications like traffic analysis [5]. YOLOv8 works in just one step, where it finds objects and also identifies what they are at the same time, making it faster than models that need two separate steps.

YOLOv8 is structured into three key sections, each playing a specific role in detecting objects effectively.

- **Backbone:** Responsible for extracting feature maps from the input image, YOLOv8 uses an improved and lightweight backbone that increases efficiency while maintaining accuracy.
- **Neck:** This component enhances the model's ability to detect objects of various sizes by combining features from different levels of the network using advanced methods like PAN (Path Aggregation Network).
- **Head:** The detection head generates final predictions, including bounding boxes, confidence scores, and class labels for each detected object [6].

By integrating YOLOv8 with a CNN-based classifier, the system not only detects vehicles in the video but also provides fine-grained recognition of each vehicle's make or model. This combination enhances the system's usefulness in intelligent traffic systems and automated transportation analytics [7].

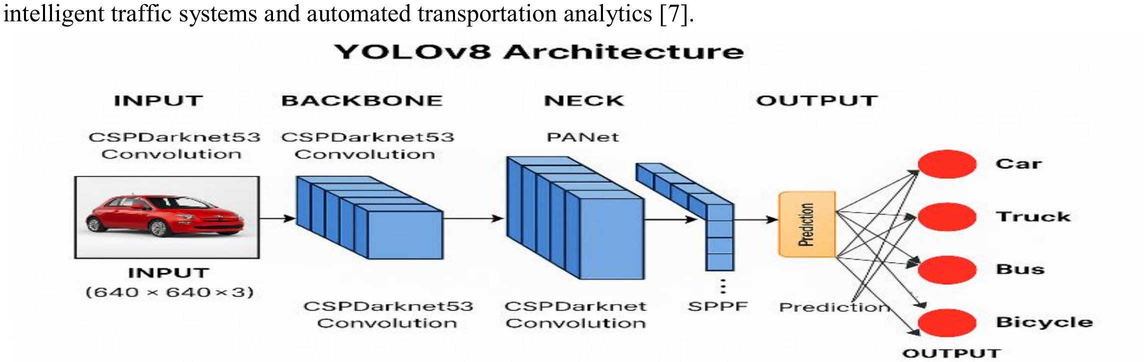


Fig.No:1.2 Architecture of YOLOv8 Networks.

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II. LITERATURE REVIEW

1. Computer Vision Application: Vehicle Counting and Classification System from Real-Time Videos. (2024)
In this paper Traffic congestion is a long-standing problem for urban planners. To solve this problem, the new system uses computer vision to identify and classify vehicles. The system takes input from traffic videos and applies a background subtraction method called the Gaussian Mixture Model (GMM) to detect moving vehicles. It then classifies vehicles using contour matching (CC) and bag-of-features (BoF) methods. This approach provides good results in vehicle identification and low maintenance costs. The system provides vehicle identification and distribution.[8]

2. Vehicle counting classification and detection using Opencv (November 2023)
In this paper, traffic counting, classification, and detection are essential for modern transportation and surveillance. OpenCV uses different models, visual search, and object-tracking algorithms for vehicle calculations. For classification, OpenCV uses a convolutional neural network (CNN) to classify vehicles such as cars, trucks, or motorcycles. For detection, OpenCV uses pre-trained models such as Haar Cascades and YOLO (You Only Look At One). This model provides strong vehicle detection and tow-box attachment. OpenCV's algorithms support real-world vehicle detection for a variety of applications.[9]

3. Computer Vision Application: Real-time vehicle counting and classification system (2022)
In this paper, Urban planners have long struggled with vehicle identification. To solve this problem, machine vision systems use Gaussian mixture model (GMM) background subtraction to detect and count vehicles. The system captures video images and classifies vehicles using contour matching (CC) and feature package (BoF). This method is economical and easy to manage. Vehicle identification becomes easier as the system can accurately identify and classify vehicles. In this project, two distribution methods are compared to achieve the best results.[10]

4. Real-time Classification and Counting of Vehicles from CCTV Videos for Traffic Surveillance Applications. (2023)
In this paper, urban planners face challenges in transportation analysis. This project presents a vision-based system that uses Gaussian mixture model (GMM) background subtraction to detect and count vehicles. The system uses contour matching (CC) and a bag of finds (BoF) methods to classify vehicles. This method is economical and easy to manage. The system can accurately identify and classify vehicles. It compares the two distribution methods to get the best result.[11]

5. Vehicle Detection and Classification via YOLOv4 and CNN over Aerial Images (2024)
In this paper, a new method is developed for vehicle detection and classification in aerial imagery. This method uses a 5-stage approach with prioritization of contrast histogram equalization (CLAHE) and fuzzy C-means segmentation. Vehicle detection is performed using YOLOv4, and fast routing, BRIEF rotation (ORB), and feature transformation (SIFT) techniques are used for feature extraction. It then uses Convolutional Neural Networks (CNNs) to recognize and classify what type of vehicle each one is. This method works with 96.1% and 96.8% efficiency on VEDAI and VAID datasets, respectively.[12]

6. Vehicle Counting and Classification for Traffic Surveillance (2022)
In this paper, Video uses special algorithms to detect and track vehicles. The system first removes the background and then identifies individual vehicles using filters. The number of vehicles can be counted accurately if the camera has a clear field of view. The system works very well, the vehicle counting accuracy is over 80%. It can be further developed and made immediately available on busy roads.[13]

7. Real Time Video based Vehicle Detection, Counting and Classification System (2023)
In this paper, Vision-based vehicle counting and distribution system creation technology. The system captures still images from video footage to identify and count vehicles. There are two classification algorithms: Bag of Features (BoF) method, which is used to capture different images of vehicles for classification; and Contour Comparison (CC), which is used to determine the contours of vehicles according to specified values. The project aims to improve vehicle detection capabilities while reducing maintenance costs compared to traditional sensor systems.[14]

8. Classification and Counting of Vehicles using Image Processing Techniques (2022)
In this paper, The system can detect and track vehicles even in traffic conditions using machine learning techniques. Vehicle detection and recognition are achieved by image processing and object tracking algorithms. The system can not

only identify the vehicles but also keep a count of how many were detected, along with their types. Improve vehicle detection using real-time CCTV surveillance.[15]

9. Lightweight Vehicle Detection and Classification in Real-Time (2024)

This paper proposes an IoT-based vehicle detection and classification system based on LiVeR. LiVeR is designed to be efficient, lightweight, self-sufficient, and suitable for outdoor use. The system can classify different vehicles with an accuracy of 91.3% to 98.8%. LiVeR can also reduce energy consumption and extend the life of the system. It uses machine learning algorithms for dynamic classification. The performance of LiVeR was demonstrated through outdoor measurements and simulations.[16]

10. Vehicle Counting Using Detecting-Tracking Combinations: A Comparative Analysis (2020|)

In this paper, Deep learning-based approaches have demonstrated high performance at low cost. In this work, search and tracking algorithms (e.g., YOLOv4 and Deep Sort) are presented to build traffic count models. The tests revealed issues such as shadowing, scale, and weather conditions. YOLOv4, Detectron2, and CenterNet detectors work best when used with a Deep Sort tracker.[17]

11. Vehicle Type Classification and Counting Using YOLOv4 Algorithm (2022)

In this paper, a model is required to complete the car counting in-car video. Vehicles such as coupe, pickup, sedan, SUV, and minibus. This allocation and calculation of resources improves traffic monitoring and management. The system achieved 92.13% classification accuracy and 89.14% counting accuracy using the YOLOv4 model. Unlike other systems that only count vehicles, this application completes the identification and classification of vehicles according to their types, providing more detailed information for vehicle identification. Overall, the system represents a significant advance in vehicle classification [18]

12. Traffic sign classification using CNN and detection using faster-RCNN and YOLOV4(2022)

In this paper, Using deep learning tools to improve driving safety. We built a convolutional neural network (CNN) that can classify 43 different traffic sign categories from the German Traffic Sign Recognition Criteria dataset with 99.20% accuracy. To identify traffic signs in real-time, we compared two state-of-the-art models: the faster R-CNN with a mean probability of detection (MAP) of 43.26% but very slow at 6 frames per second, and the YOLOv4 with a mean precision (MAP) of 1.) is 59.88% faster at up to 35 frames per second and is suitable for on-the-fly applications. Our system is tested under extremely harsh conditions to ensure it is reliable and robust in a wide range of situations.[19]

13. Vehicle Classification and Counting System Using YOLO Object Detection Technology (2021)

This research focuses on improving urban surveillance using technologies such as YOLO object detection and deep learning. Using high-resolution sensors, the system can detect and identify vehicle types in a variety of configurations, including straight roads and intersections. Imaging equipment is used to track vehicles crossing the counting line. This study evaluated the accuracy of vehicle counts and provided data that can be compared with real-time measurements. The results were obtained from multi-time calculations and analyzed using non-conformant matrices to assess validity. [20]

14. Vehicles Detection Using YOLOV3 For Counting The Vehicles and Traffic Analysis (2022)

In this paper, The research focused on urban traffic monitoring to improve smart city traffic management. In this study, Python, OpenCV, and YOLOv3 object detection tools are used to capture live video from Sony HD IP cameras to identify and count vehicles in real time. Each frame in the video is processed to remove the background and show moving vehicles. Supported by a pre-trained model called darknet, YOLOv3 classifies different vehicles such as buses, cars, and motorcycles, and tracks their movements. This study aims to increase the accuracy of vehicle identification and classification compared to traditional methods. It also uses line diagrams to visualize vehicle alignment and provides valuable information for traffic management and infrastructure planning.[21]

15. Development of Vehicle Detection and Counting Systems with UAV Cameras: Deep Learning and Darknet Algorithms (2023)

In this paper, Vehicles traveling on the highway at an altitude of 350-400 meters. To achieve this goal, various convolutional neural network (CNN) models are used, including YOLOv3, YOLOv4, YOLOv7, DenseNet201-YOLOv3, and CSResNext50-Panet-SPP. The study found that the CSResNext50-Panet-SPP model has the highest accuracy by detecting all vehicles in the video data, while other models such as DenseNet201-YOLOv3 and YOLOv4

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also performed well in vehicle identification with 98% to 99% accuracy. . . Although only five of these models could be fully optimized due to hardware limitations, the study shows that vehicle detection capabilities can be improved by including multiple groups and improving hardware support.[22]

16. Vehicle Detection System& Counting of Vehicles in Still Images Using Deep Learning (2022)

In this paper, Develop a vehicle detection and counting system to improve road management by identifying and counting vehicles of different sizes and shapes. The system uses YOLOv3, a powerful algorithm designed for real-time object detection, to identify and count multiple vehicles in CCTV images. With this process done in Google Collab, in-car video footage can be processed efficiently and results can be obtained with 99% accuracy in about 5 minutes. This makes it a great tool for traffic monitoring and road management.[23]

17. Vehicle Classification and Counting for Traffic Analysis based on Single-stage YOLOv8 Model (2024)

This project introduces a traffic monitoring system that uses the YOLOv8 deep learning model to detect, classify, and count vehicles from video. It can recognize four types of vehicles: cars, buses, trucks, and motorcycles, and keeps track of how many of each are seen during the video. The system runs on an NVIDIA GTX 1070 GPU. YOLOv8 was chosen for this task because it works quickly and gives accurate results, making it suitable for object detection in traffic scenes.[24]

18. Real-Time Vehicle Detection and Counting for Traffic Management System(2025)

This project is designed to detect and count vehicles from video to help with traffic control and monitoring. It automatically counts vehicles while handling common challenges like poor lighting, overlapping vehicles, and different vehicle shapes and sizes. For detection, it uses the YOLOv8 deep learning model, which provides high accuracy. To track vehicle movement across video frames, a centroid-based tracking method is used. YOLOv8 performs better than YOLOv5, making it a good fit for tasks like traffic flow analysis and managing road congestion.[25]

19. Real-Time Vehicle Detection Using YOLOv8 Model(2024)

This project is about identifying vehicles quickly and accurately using the YOLOv8 (You Only Look Once version 8) deep learning model. The goal is to make detection faster and more reliable when working with video from live cameras. This can help improve smart traffic systems, such as those that adjust traffic signals based on vehicle movement.[26]

III. PROPOSED WORK AND METHODOLOGY

The goal of this project is to build a deep learning-based system that can automatically detect, identify, and count cars from video input. The system follows two main stages to ensure accurate and effective performance.

1. First, a Convolutional Neural Network (CNN) is used to recognize the specific make or model of each car by analyzing its visual details.
2. Next, the YOLOv8 object detection model is used to locate and track cars in each frame of the video.

The CNN is trained using a custom car image dataset that includes models like Swift, Audi, Innova, and Tata Safari.

3.1 Dataset Preprocessing

Before training the CNN, several preprocessing steps are applied to prepare the dataset and improve model performance:

- **Image Resizing:** All vehicle images are resized to a consistent size of 128×128 pixels with 3 color channels (RGB). This standardization helps maintain uniform input across the entire dataset.
- **Normalization:** Pixel values are scaled to a range between 0 and 1 by dividing by 255. This improves the speed and stability of training.
- **Data Augmentation:** To increase the diversity of training samples and reduce overfitting, several augmentation techniques are applied:
- Image rotation:
- Horizontal flipping

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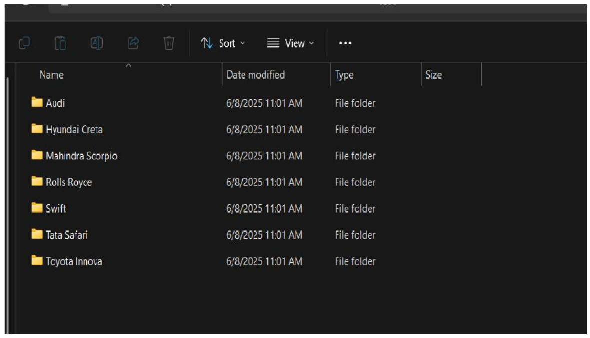
- Zooming in/out
- Adjusting brightness and contrast

Label Encoding: Vehicle class labels (e.g., car_Audi, car_Swift) are converted into one-hot encoded vectors, which allows the CNN to perform multi-class classification effectively.



3.2 CNN Architecture for Vehicle Classification

Once the dataset is ready, the CNN model is used to classify each detected vehicle. The process follows these key steps:

Step 1: Input Layer : Each vehicle image, resized to 128 by 128 pixels with three color channels, is fed into the neural network for analysis.

Step 2: Convolutional Layers: Filters scan the image to capture essential features like shapes, edges, and patterns that differentiate vehicle models.

Step 3: ReLU Activation Function: Non-linear activation is applied to retain only meaningful (positive) signals.

ReLU(x) = max(0, x)

Step 4: Pooling Layer :Max pooling is used to reduce the size of feature maps, which speeds up training and keeps important features.

Step 5: Flattening : After feature extraction through convolution and pooling, the result is converted into a single long vector, making it ready for the final classification layers.

Step 6: Fully Connected Layers : These layers analyze extracted features and predict the vehicle class using a Softmax activation function.

Example Output Classes: car_Swift , car_Tata Safari , car Mahindra scorpio , car_Audi

3.3 YOLOv8 Detection and Counting

YOLOv8 (You Only Look Once – version 8) is a modern and efficient deep learning model for real-time object detection. It is capable of detecting multiple objects in video frames quickly and with high accuracy.

Step 1: Video Frame Input : The system reads each frame of the input video using OpenCV and sends it for processing.

Step 2: Vehicle Detection with YOLOv8 : YOLOv8 identifies of vehicles, including cars. It places bounding boxes around detected vehicles and assigns general labels such as "car".

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Step 3: Cropping Detected Vehicles : After detection, each vehicle is cropped from the frame and sent to the CNN for more specific classification (e.g., to determine if it's a Swift or an Audi).
Step 4: Vehicle Counting : The number of detected vehicles is continuously updated:
Step 5: Output Display with Annotations : In the final video: A bounding box is drawn around each detected vehicle The CNN-generated class label (e.g., car_Swift) is shown above the box.
The number of detected vehicles is updated live and shown directly on the video output.

Frame	VehicleID	Company	X	Y	Width	Height
1	1	Rolls Royce	682	881	205	199
1	2	Rolls Royce	1531	720	247	128
1	3	Rolls Royce	1249	934	322	145
1	4	Toyota Inno	936	766	182	193
1	5	Tata Safari	522	532	100	102
1	6	Toyota Inno	689	575	102	111
1	7	Tata Safari	624	477	74	78
1	8	Audi	703	478	103	97
1	9	Rolls Royce	1337	604	151	95
1	10	Audi	659	408	68	66
1	11	Toyota Inno	1249	542	97	61
1	12	Rolls Royce	1257	656	207	143
1	13	Tata Safari	1729	745	190	278
1	14	Toyota Inno	712	370	55	40
2	15	Rolls Royce	685	904	216	176
2	16	Rolls Royce	1521	710	248	130
2	17	Rolls Royce	1258	948	309	131
2	18	Toyota Inno	948	783	192	213
2	19	Toyota Inno	688	583	105	104
2	20	Swift	708	480	91	81
2	21	Tata Safari	621	478	75	78
2	22	Audi	517	533	105	108
2	23	Rolls Royce	1332	604	151	88
2	24	Tata Safari	515	566	94	76
2	25	Audi	659	415	66	64
2	26	Rolls Royce	1218	531	124	68
2	27	Toyota Inno	825	439	63	52
2	28	Rolls Royce	1260	646	190	131

detections

IV. CONCLUSION

This project presents a smart and automated system for identifying, counting, and classifying various types of vehicles from traffic video footage. By integrating the YOLOv8 model for fast and accurate vehicle detection with a Convolutional Neural Network (CNN) for detailed classification, the system provides a reliable approach for real-time traffic monitoring. YOLOv8 detects the location of vehicles in each video frame, while the CNN model classifies them into specific categories such as car models, buses, motorcycles, and trucks. Together, these two components enable a deeper understanding of traffic scenes. Looking ahead, the system can be enhanced in several ways:
Optimize it to run efficiently on lightweight devices such as smartphones.
Expand the classification model to recognize more vehicle types and models.
Improve performance under challenging conditions, such as low light, rain, or traffic congestion.
By incorporating these improvements, the system can play a more effective role in intelligent traffic systems, enabling better planning, control, and analysis in smart cities.

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