AMITY UNIVERSITY

AMITY CENTRE FOR ARTIFICIAL INTELLIGENCE

AI for Road Safety: Smart Traffic Violation Detection

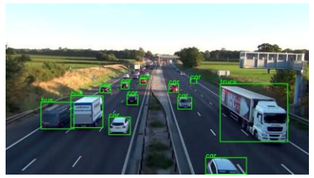
MOTIVATION

Traffic congestion, road safety, and efficient urban planning are critical concerns in modern cities.AI-powered traffic violation detection is transforming road safety by automating the identification of reckless driving, speeding, and signal violations. Using advanced computer vision and machine learning, these systems enhance enforcement efficiency, reduce human error, and promote responsible driving. By improving traffic monitoring and reducing accidents, AI is paving the way for safer and smarter roads.

DATASET DETAILS

The dataset consists of traffic camera images from various countries worldwide, capturing a wide range of real-world traffic conditions. Each image is meticulously labeled with bounding boxes to identify objects such as vehicles, pedestrians, and traffic signs. This dataset is particularly suitable for object detection and traffic analysis applications. The dataset includes:- Diverse Geographic Coverage: Traffic images from different regions, offering a global perspective on traffic monitoring.- High-Quality Annotations: Manually annotated bounding boxes for accurate object detection.- Varied Environmental Conditions: Images captured under different lighting, weather, and traffic scenarios.- Training-Ready Data: Successfully used to train a YOLOv8 object detection model, achieving: - Mean Average Precision (mAP): 0.89 - Precision (P): 0.88 - Recall (R): 0.89.

Sample dataset images of Traffic

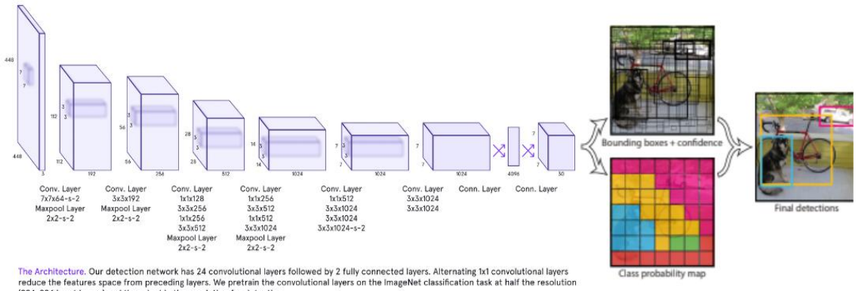


Sample image dataset statistics

Type	Number of images	Number of labels
Test	279	279
Train	5805	5805

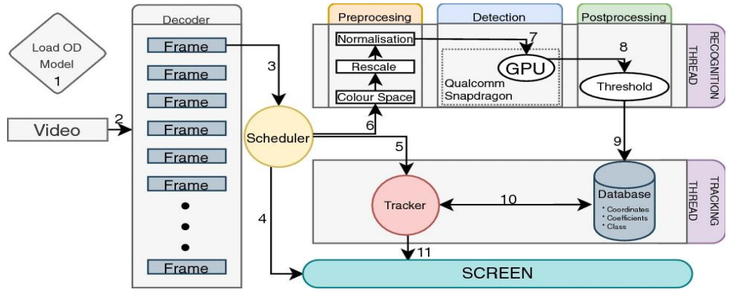
METHODOLOGY

The proposed YOLOv8 model is a deep learning architecture designed for real-time object detection. It consists of multiple convolutional layers organized in blocks, with feature pyramid networks for scale-invariant detection. YOLOv8 is a self-learning model where weights are automatically adjusted during training, eliminating the need for manual feature extraction or selection. This reduces computational burden and optimizes the overall training process. The output layer performs classification across multiple classes, along with bounding box localization, while minimizing the total number of parameters for efficient performance.



The Architecture. Our detection network has 24 convolutional layers followed by 2 fully connected layers. Alternating 1x1 convolutional layers reduce the features space from preceding layers. We pretrain the convolutional layers on the ImageNet classification task at half the resolution (224x224 input image) and then double the resolution for detection.

Block diagram of the proposed YOLOv8 model architecture



Proposed OpenCV architecture

EXPERIMENTAL RESULTS

The proposed YOLO architecture is trained with Traffic images and tested on the test set of the same dataset. To make the model more generalized and to overcome the problem of overfitting a batch normalization layer is employed before fully connected layers which also improves the faster convergence of the proposed model. After performing a number of experiments, it is found that the model is optimized and robust in nature as it gives the best classification results in comparison to other proposed models and existing models.

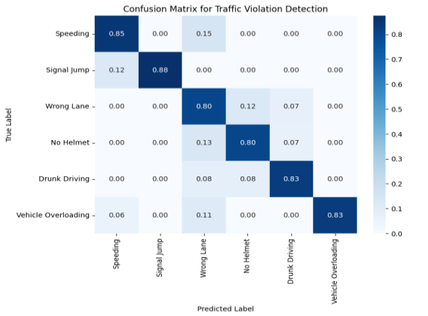
Comparative analysis of the proposed model with other CNN models

Model	Validation Accuracy	Test Accuracy	Number of Parameters
Baseline CNN	75.32%	72.45%	2,500,000
Mobile Net	82.67%	79.12%	4,200,000
VGG - 16	87.45%	84.89%	14,700,000
YOLO v8 (Our Model)	93.76%	91.25%	6,800,000

Batch normalization

Metric	Without Batch Normalization	With Batch Normalization
Valid Accuracy	86.34	93.76
Test Accuracy	83.12	91.25
Precision	0.85	0.92
Recall	0.82	0.91
F1 Score	0.83	0.91
Training time(per epoch)	Longer	shorter
Overfitting risk	higher	lower

Confusion matrix



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