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SMART TRAFFIC VIOLATION DETECTION SYSTEM

[1]Mr. Ram Gawhane, [2]Mr. Vivek Jayakumaran, [3]Mr. Sparsh Verma, [4]Mr. Rohit Yadav, [5]Mrs. Jayashree Hajgude

[1,2,3,4]Student, [5]Asst. Professor

Vivekanand Education Society Institute of Technology,
Chembur, Mumbai

Abstract: In recent years, there has been a steady rise in the number of road accidents in India, resulting in a rise in injuries and fatalities. Particularly, the failure of motorcyclists to wear helmets is one of the significant contributors to severe injuries and casualties in road accidents. The rise in population and the growing number of motorcyclists on the road have made police patrolling challenging and labor-intensive. The proposed system aims to address this issue by developing a specialized computing model designed to identify motorcyclists not wearing helmets. Upon successful detection, the system promptly retrieves the vehicle's number plate and transmits this vital information to relevant authorities for necessary action. This involves issuing an automated challan to the violator and stating the reason for the fine. The application utilizes the YOLO (You Only Look Once) computer vision algorithm, known for its efficiency in real-time object detection and classification. Recently, a new version of the YOLOv8 algorithm has been developed by Ultralytics, taking into account the limitations of its predecessor models. With a focus on speed, accuracy, and user-friendly design, YOLOv8 is a robust choice for various computer vision tasks. Its capabilities extend to object detection and tracking, instance segmentation, and image classification, demonstrating a flexible and high-performance solution for diverse applications. This integration of technology tackles the critical issue of helmetless driving, thereby promoting road safety by enhancing stricter measures. By automating the identification and penalty processes, the proposed system aims to optimize enforcement efforts, ensuring a safer environment for all commuters.

***Index Terms* -** Road accidents, injuries, fatalities, helmet non-compliance, computer model, YOLOv8, real-time object detection, automated challan, road safety, enforcement automation.

I. INTRODUCTION

There has been a steep increase in the number of road accidents caused by reckless driving, overspeeding, and lack of helmet usage, raising serious concerns for road safety. Ensuring road safety and compliance with traffic regulations remains a challenging condition due to the vast number of vehicles on the road.

According to a survey conducted in 2020, there were a total of 326 million registered vehicles in India. Out of this, 75% of them are 2-wheelers. It was concluded that 47% of Indian households have a 2-wheeler at their place. According to the report titled 'Road Accidents in India -2022' published by the government, there were a total of 4,61,312 accidents that occurred [1] in the year 2022, which claimed 1,68,491 lives. Out of the fatalities reported, 44.5% of them were motorcyclists, with Tamil Nadu with the highest number of accidents.

Currently, there are two ways adopted by the traffic authorities to check for helmetless riders. One is a manual technique in which the traffic police monitor the road and issue fines to the traffic violators. In case the violator attempts to escape, a photograph of the biker is taken by the police to maintain accountability. Given the vast number of vehicles on the road, it becomes a tedious task for traffic officials to catch them. Another method is the use of Surveillance cameras. Surveillance cameras play a crucial role in monitoring traffic, but identifying high-speed motorcycles, especially those without helmets, and their number plates poses a significant challenge. Moreover, the variation in the dimensions of number plates for motorcyclists and other vehicles is an additional challenge for the identification process.

As a result, with the growing population and the number of motorcyclists on the road, there is an urgent need to address this issue. The application proposed in the paper makes the challan system automated for the higher authorities. The system detects motorcyclists either through video input or image capture and classifies them whether they are wearing helmets or not. The number plate of the motorcyclist is recorded through OCR for the one not wearing a helmet on the number plate and is verified by the higher officials to make challan to the respective rider, thereby making the task of traffic authorities hassle-free.

II.LITERATURE SURVEY

Several papers have been published in contrast with the Helmetless detection of motorcyclists and traffic violators emphasizing the seriousness of road safety. The research paper [2] introduces a system for automated detection of motorcyclists without helmets using CCTV videos, along with license plate detection. The model is implemented using Convolutional Neural Networks (CNNs) and transfer learning from pre-trained VGG-16 networks. It begins with background subtraction of the environment and object segmentation using Canny edge detection, leading to the classification of moving objects as motorcyclists or non-motorcyclists. If a motorcyclist is identified, head detection is performed, and a CNN module is used to distinguish among helmet and helmetless riders. Subsequently, the system detects and localizes number plates on target motorcycles, employing various image processing techniques. The individual characters on the number plates are segmented and subjected to Optical Character Recognition (OCR). Experimental results on CCTV cameras had high accuracy for both motorcyclist detection (98.72%) and OCR (96.36%).

Another paper [3] made use of YOLOv3 for the detection of motorcyclists and CNN for helmet detection. The YOLOv3 model is used for motorcycle and person detection in traffic surveillance videos. The Euclidean Distance between bounding boxes is measured to identify motorcyclists. A CNN module is employed for helmet detection. The input for the model is with the top one-fourth portion of the motorcycle rider's head serving as input. The CNN architecture consists of five convolutional layers, achieving accurate helmet detection.

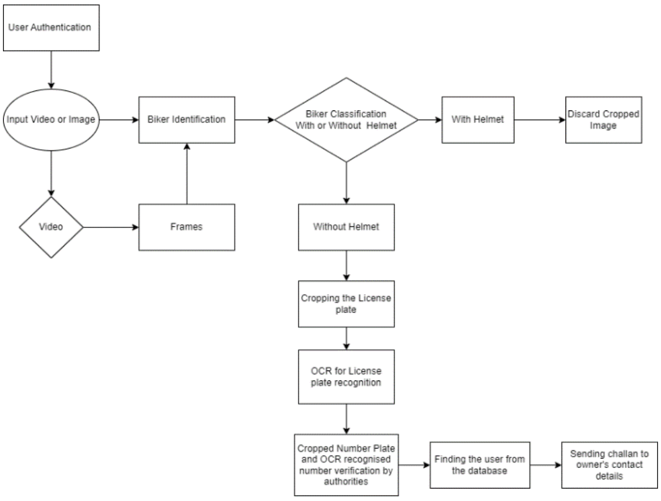
An advanced version of YOLOv3, YOLOv5 was used in [4] for object detection which is faster than its previous version in terms of speed and accuracy. The model distinguishes three types of riders: motorcycle, bicycle, and tricycle to avoid false detection rates among the riders. Helmet and motorcyclist images were taken from the HFUT-MH dataset. The pre-trained model from the COCO dataset is used to tune the YOLOv5 model.

In [4], an automatic challan generation ticketing system is built. In this, the model is fed with live CCTV footage in which an image is captured of the rider not wearing a helmet. Then the image is fed to the API for object detection and license plate detection, and the recorded number plate is presented to the higher authorities in the form of a GUI with an image of the number plate to take further actions.

In [5], the CNN model is used to classify the images of the dataset. The three-class labels Helmet, no helmet, and license plate of motorcyclists were detected. The model recorded a precision of 81% for motorcyclists with and without helmets. Another paper [11] discussed the use of tensorflow for helmet detection for workers in substation for their safety purpose.

III.PROPOSED METHODOLOGY

The proposed solution is a mobile application developed for fast and efficient fine allocation for non-helmet riders. The officer using this app has to authenticate to login into the application. The proposed model makes use of three YOLOv8 models(You Only Look Once) for detecting multiple objects in a single frame. The authority has the option to provide input to the system in different available formats i.e., videos and images for processing. After processing, the model will detect all riders not wearing a helmet and detect their number plates. The numbers are recognized by an OCR module and the cropped image of the number plates and the detected number plate is shown to the authority for final verification and is allowed to make changes if required. After verification, the authority can send the challans to respective users from the mobile application. This solution is thereby time efficient and can minimize the time and human work to implement helmet compulsion by automating the major part of the fine allocation system.



To train the model, we have considered four key constraints - task, epochs, imgsz, and model.

- Epoch refers to one complete pass across the entire dataset during training. It refers to the number of times the model scans the entire dataset.
- Imgsz refers to the dimensions of the image trained by the model.
- Model refers to its capacity. There are five types: n, s, m, l, and x according to the capacity of the model.
- Task refers to the objective the model is trying to solve such as classification, detection etc.

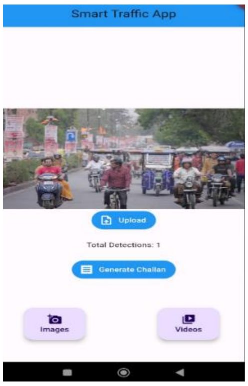
Comparison of different performance metrics of YOLOv8 model

Model	size (pixels)	Speed CPU ONNX (ms)	Speed A100 TensorRT (ms)
YOLOv8n	640	80.4	0.99
YOLOv8s	640	128.4	1.20
YOLOv8m	640	234.7	1.83
YOLOv8l	640	375.2	2.39
YOLOv8x	640	479.1	3.53

As the size of the YOLO model increases, its accuracy and processing time increases. Hence from the above table, we have selected the 'YOLOv8m' model for balance between accuracy and processing for all object detection tasks in the proposed solution. The processing speed and accuracy of the model can be drastically increased if the specialized hardware is used during the deployment of the proposed solution.

A. Providing input to the application

The authorized police official initially has the control to input data to the application using three options. First is to provide the image via camera, the second is to select multiple pre-captured images and the third is the use of video. If video is provided as input to the system then it is first converted into frames before sending for further processing. These images/frames are then sent to the YOLOv8 model for object detection.



UI option for submitting the input

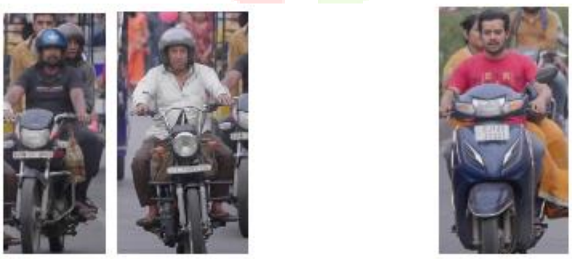
B. Motorcyclist Detection

Dataset of 770 images [12]of people riding motorcycles with various angles is used to train the model. Out of 770 images, 536 images are used for training, 156 for validation, and the rest for testing. The dataset is annotated with a class named rider which will detect the motorcyclist from the image fed into the model. Imgsz is preset to 680 for this with epochs to 100 and model 'm'. Each annotated image contains a label indicating the rider in the given image. The dataset contains images of bikers from multiple angles for more accurate results. After the rider detection, the rider image is cropped and then forwarded for the helmet detection model.

Cropping all the motorcyclists in the image

C. Helmet Detection

The cropped image of the motorcyclist is then forwarded to the helmet detector. The helmet detector is trained on a dataset containing 1376 images [13]with two classes for detection which are "With Helmet" and "Without Helmet" with 50 epochs and 640 imgsz. 126 images are for validation and 63 are for training. The proposed solution checks if there is any helmet detected in the cropped biker image. If there is any detection of a helmet, the image is rejected for further processing.



Riders with helmet are discarded from further processing

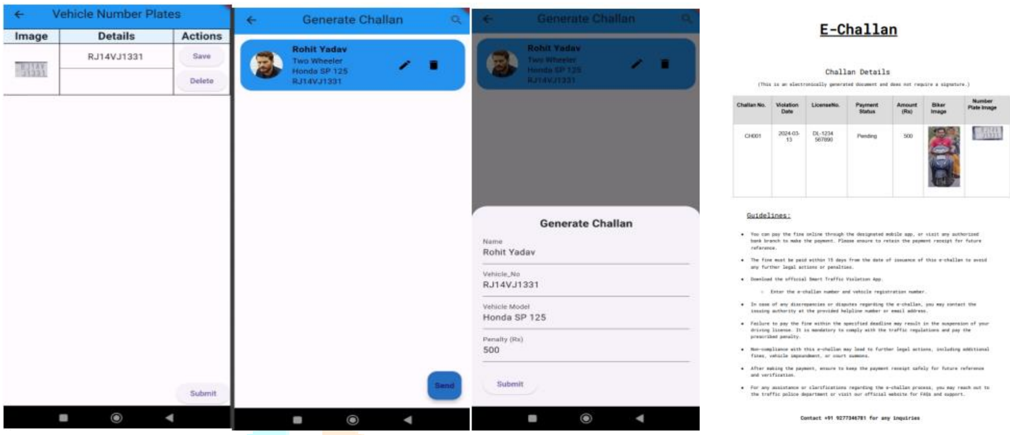
D. Number Plate Detection

This model crops the license plate [14] of a non-helmet rider from the cropped image. This license plate was then converted to black and white [15] for better results of OCR. After conversion, the license plate is then processed by the EasyOCR module for extraction of letters from the number plate. The extracted characters are then presented to authority along with the cropped image of the number plate for final verification.

Number Plate cropped and converted to black and white for better recognition

E. Verification and Challan

The verification step is included to minimize the inaccurate license plate recognition. The authority can change the recognized number by referencing it to the cropped license plate image shown in the UI. After verification of all the number plates authority can see all the vehicle owners in the UI. After that, the authority can allocate a fine to all the fetched users to their respective email IDs through the application. The allocated fine will contain the image of the rider, cropped number plate, and recognised number along with old fines on the vehicle in an auto-generated pdf format.

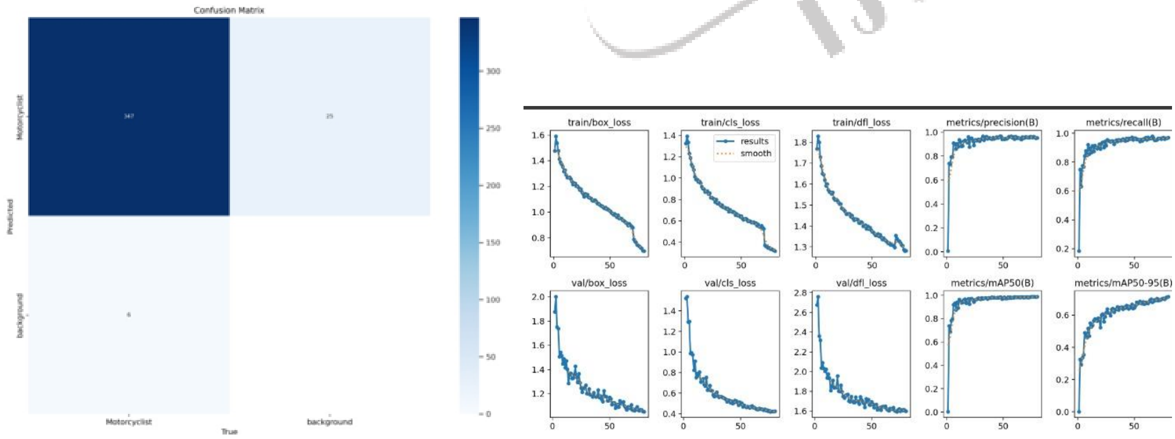


Recognised number plate verified by authority and challan issued through UI

IV. RESULTS AND DISCUSSION

1) Motorcyclist Detection Model

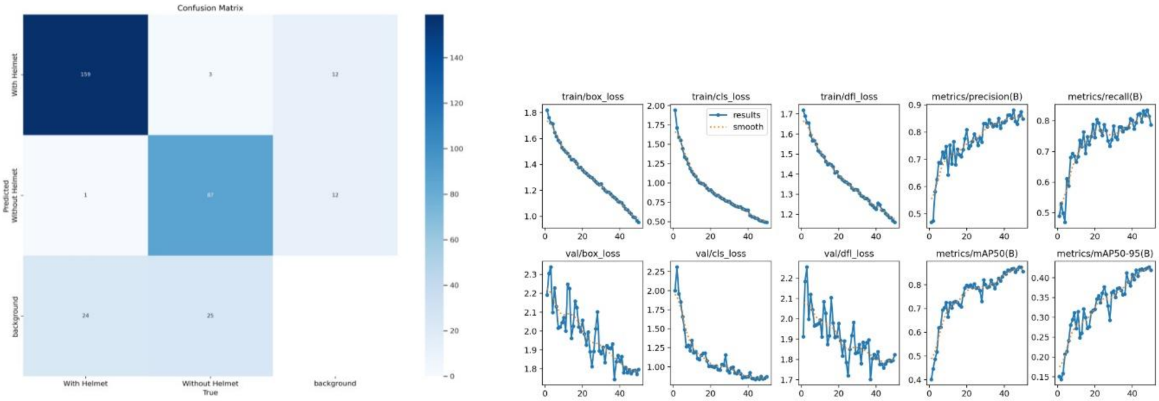
The model trained for motorcycle detection has following loss and metric graphs. For a successful training process the map graphs should be similar to a decreasing exponential curve becoming flat at the end and the metric graph should be an exponential increasing curve becoming flat at the ending values. Following are the graphs for all the respective values after each respective epoch. After training the model, the following curves are obtained as shown in below figure for motorcyclist detection. The accuracy of the model is found to be 91% along with a precision of 93% and recall of 98%. The time taken by model to detect the motorcyclist is found to be 401.6ms. The model resized the given image to 384 x 640 pixels.



Confusion matrix and results after training process of motorcyclist detection model

2) Helmet Detection Model

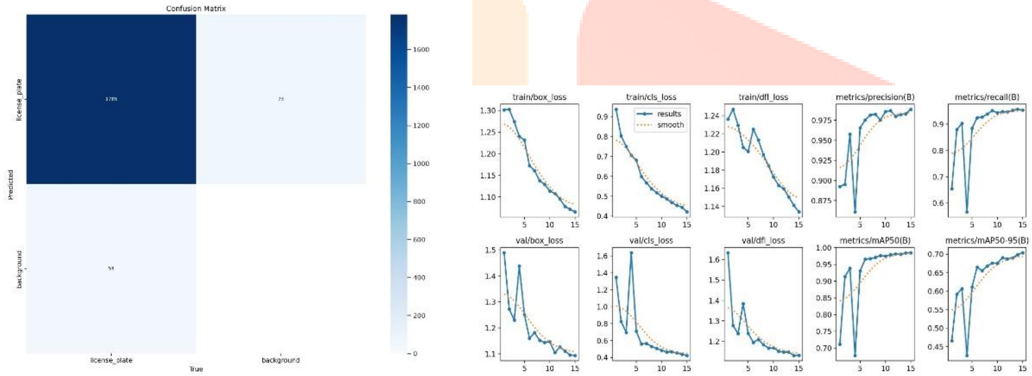
This model detects two classes “With Helmet” and “Without Helmet”. After training the model, the following curves are obtained as shown below for helmet detection. The accuracy of the model is found to be 80% along with a precision of 91.37% and recall of 86.41% for “With Helmet” class.For “Without Helmet” class, the accuracy of the model is found to be 80% along with a precision of 87% and recall of 75.65%. The time taken by model to detect the head of riders with helmet is 360.6ms and without helmet is 359.4ms. The model resized the given cropped image of motorcyclist to 640 x 352 pixels.



Confusion matrix and results after training process of helmet detection model

3) License Plate Detection

This model detects the number plates in the cropped image of bikers. The graph shown below shows the results produced and expected behavior after a successful training process. The accuracy of the model is found to be 93% along with a precision of 96% and recall of 97%. The time taken by the model to detect the number plate is found to be 343.2ms. The model resized the given cropped image of motorcyclist to 640 x 384 pixels.



Confusion matrix and results after training process of license plate detection model

Following table shows the performance metrics such as accuracy, precision and recall for each of the trained model

Sr No.	Model	Accuracy	Precision	Recall
1	Biker Detection	91%	93%	98%
2	Helmet Detection	80%	91.37%	86.41%
3	Non- Helmet rider Detection	80%	87%	75.65%
4	Number Plate Detection	93%	96%	97%

Detection time of each model along with the resized image size in pixels is shown in the below figure. The detection time was observed on system with Intel-i5-1135G7 processor without any dedicated GPU

Sr No.	Model	Resized Image (pixels)	Detection Time (ms)
1	Biker Detection	384 x 640	401.6
2	Helmet Detection	640 x 352	360.6
3	Non- Helmet rider Detection	640 x 352	359.4
4	Number Plate Detection	640 x 384	343.2

V. Conclusion

To conclude, this paper emphasizes on building a system for number plate detection of helmetless motorcyclists and issue challan for the same. The model recorded an accuracy of 91% for motorcyclists, 80% for helmet detection and 93% for number plate segmentation. This model aims to ease the work of traffic officials for issuing challan manually and make the entire process of detecting the traffic violators time efficient, thereby reducing road accidents and making a safer travel for the pedestrians.

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