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SafeDrive AI: Revolutionizing Traffic Monitoring with Helmet and Number Plate Recognition

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ABSTRACT: The current scenario of India's traffic laws poses a number of challenges, each of which may be addressed in a variety of ways. An increasing incidence of motorbike and moped-related fatalities have been linked to the common practice of driving without a headgear in India. The current system relies heavily on CCTV records to keep tabs on traffic offences, forcing cops to manually examine individual frames and, if the rider isn't wearing a helmet, focus in on their numberplate. However, this calls for a significant investment of time and resources, since traffic offences are common and the number of motorcyclists grows daily. What if there were a technology that could detect whether or not a motorcyclist was breaking the law by failing to wear a helmet and, if so, get the vehicle's registration number from the database? This study has been accomplished with recent success using Haar, HoG, L BP, R-CNN, CNN features, etc. However, the pace, precision, and effectiveness of object identification and categorization are severely constrained by these works. In an effort to automate the process of finding instances of the traffic offense of not donning a headgear and retrieving the numberplate of vehicles, this study develops a Non-Helmet Driver identification method. The core idea is to use three tiers of DL for Image Classification. Individual, motor bike, headgear, and license plate are all recognized utilizing YOLOv5's increasing levels of sophistication. Particularly for the extraction of license plate numbers, all of these methods are governed by a set of predetermined parameters and limits. Since moving images are used as input, the processing time is critical. By combining the aforementioned methods, we have developed a comprehensive system for identifying helmets and extracting license plate numbers.

KEYWORDS: CNN, Deep learning, Image Classification, YOLOv5, OCR.

I. INTRODUCTION

In a research published under the title "The global study on traffic safety 2022," the Globe Health Agency found that traffic crashes cause over 3 million deaths and 1.5 million injuries usually worldwide.

Based on the research presented in this paper, a comprehensive action plan is required to stop unnecessary deaths. Unfortunately, India leads the globe in the number of fatalities from auto accidents. Experts have hypothesized that a variety of variables, including as the growing number of megacities and the general disdain for fundamental safety procedures like using a seatbelt or helmet when driving, may be to blame for the surge in traffic fatalities. India committed to halving the number of traffic-related deaths by the year 2020 when it endorsed the Madrid Statement on Traffic Safety in 2017.

While the incidence of fatal traffic accidents in India has decreased, officials there must acknowledge that problems persist. Because of the sudden slowness brought on by impact, the rider of a motorbike or scooter is frequently forced from the vehicle in the case of a collision. The body's weight implies that even if the neck stops moving after impact, it will continue to move until it strikes the inside of the skull. In rare circumstances, a serious brain injury may prove to be fatal. In an emergency like this, a helmet is invaluable. A helmet essentially inhibits the head from moving since it reduces the possibility that the skull may be slowed down.

The interior cushion of the helmet will absorb the majority of the impact in the event of an accident and finally bring the head to rest. Additionally, it shields the skull from injury by distributing the force across a larger area, cushioning the blow. A high-quality complete helmet serves as a physical barrier between the rider's head and

whatever they hit with in the event of an accident, potentially preventing or at least reducing the severity of head injuries. The goal of traffic laws' professionalism is to lessen the likelihood of collisions and the deaths that may result from them. Nevertheless, these rules are not followed in reality.

This implies that strategies that are both workable and efficient must be created. It is now possible to manually monitor traffic using closed-circuit television. To achieve the objective, nevertheless, a lot of repeats are needed in this instance. Cities with a high population density and traffic volume cannot afford to depend solely on this laborious, manual method of helmet identification. We provide a method for comprehensive helmet recognition and license plate retrieval using OCR, YOLOv5.

A real-time object recognition system called YOLO is able to identify things in both moving and stationary photos. The YOLO algorithm has a more recent, accurate version known as YOLO v5. With OCR, text can be retrieved from images and videos. Reading license plate numbers from photos is just one of the several potential uses.

When combined with optical character recognition and YOLO v5, it is possible to locate and get the license plate numbers of motorcycle riders who do not wear helmets. The YOLO v5 algorithm can recognize motorcycle riders in images or videos, and optical character recognition can read the number plate number. This information could be utilized to find helmet rule violations.

II. LITERATURE SURVEY

Aniruddha et al. , proposed a framework to detect helmet violations and crosswalk violations. The framework consists of models running in sequential order, beginning with detecting all vehicles in the frame using YOLO, and then each vehicle being cross-checked for helmet violations. The Helmet violation is detected using a CNN-based classifier and the crosswalk violation is detected using instance segmentation by mask R-CNN architecture.

Chiverton proposed an approach to classify and track motorcycle riders with and without helmets. The author proposes the use of a Support Vector Machine (SVM) trained on histograms derived from cropped images of helmets of riders for classification. For Detection, the motorcycle riders are segmented from data using background subtraction and the heads of the riders are isolated and then classified using a trained classifier.

Dahiya et al. proposed a similar approach for helmet detection by first detecting bike riders using background subtraction and object segmentation. Then to determine whether the bike rider is using a helmet or not using visual features and a binary classifier. Wang et al. improved the background-updating algorithm by using wavelet transform on the dynamic background and then tracking moving vehicles by feature-based tracking method for more fast and accurate detection and tracking. Mallela et al. proposed a deep learning framework using a convolutional neural network-based YOLO algorithm for the detection of the number of persons riding a bike to classify violations. Reddy et al. [14], proposed using YOLO to detect persons and motorcycles. Further, to detect the helmet present in the image they used HOG features and an SVM classifier trained on color histogram features of helmets.

Mandal et al. , performed a detailed survey of object detection and tracking algorithms for vehicle counting. The authors compare the current state-of-the-art object detection models like YOLOv3, Efficient Det along with several object-tracking techniques to find the most accurate algorithm for vehicle tracking and counting. The algorithm was tested in daylight, night light, and rainy conditions. The counting results show that the best performing model combinations were YOLOv3 and tracker Deep SORT across all types of vehicles.

Kumari et al. proposed a system to automatically detect number plates with initial pre-processing done with gray scaling, thresholding, and an unwanted line elimination algorithm to remove unwanted lines from the image. Then a Sobel operator is used to extract the extracts edges from the image, and then the plate region is extracted using the aspect ratio. Hough transformation is used for feature extraction and Artificial Neural Network (ANN) is used for character recognition. Gaussian and median filters are proposed to deal with different illumination conditions.

Kocer et al. proposed a similar approach with canny edge detection being used for localization of the plate. Contrast extension and median filtering are used to enhance the image for segmentation. And finally, for character recognition, they used ANNs. Singh et al. proposed a deep learning-based approach, where a Faster RCNN - InceptionV2 which is trained on the Coco dataset for detection of number plate. After basic pre-processing, Tesseract LSTM-OCR engine was used for segmentation and recognizing text within a cropped number plate. Authors have used Yolo-v2 for vehicle detection and the Fast-YOLO model for Number Plate detection. A character segmentation CNN and a character recognition CNN are trained for final predictions.

III. PROBLEM STATEMENT

Road safety is the most important aspect of this automobile driven technological world. Considering the number of people taking road transport as the means to reach their destination, the number of people reaching the heavens instead of their safe home, is increasing day-to-day. The irresponsible driving of the two-wheelers or the heavy speeding of the four-wheelers is the major reason for the occurring accidents. These irresponsible drivers are making it hard for the drivers that follow the traffic rules. The current increase in the fine/challan system might control these irresponsible drivers to an extent, but this is not a permanent solution that we can rely on.

3.1 Existing Systems

Existing system monitors the traffic violations primarily through CCTV recordings, where the traffic police must investigate the frame where the traffic violation is happening, zoom into the license plate in case rider is not wearing helmet. But this requires lot of manpower and time as the traffic violations frequently and the number of people using motorcycles is increasing day-by-day. What if there is a system, which would automatically look for traffic violation of not wearing helmet while riding motorcycle and if so, would automatically extract the vehicles license plate number.

3.2 Proposed System

In this section, we will explain the proposed end-to-end system to automate traffic violation detection and ticketing. The system consists of three major components namely: vehicle detection, vehicle tracking, number plate detection.

- We first obtain the frames from the live footage as input to perform violation detection using an Object detection module. The violation covered for our study is not wearing helmets in Indian scenario. The object detection is carried out using YOLO-v5 object detector to detect one or more violations in each image frame.
- **Object tracking model:** The detected object is then tracked using the object tracking model to avoid repetitive counting and to ensure capturing the vehicles across multiple frames.
- **License plate detection:** After detecting and tracking the violations, each violating vehicle is cropped out using the coordinates obtained from bounding boxes given by object detection module of vehicle detector module. YOLO-V5 is used for the detection of the number plate of a vehicle from cropped vehicle images. Tesseract is used for OCR (Optical Character Recognition) is used to extract the license numbers from the number plate and store them in a database.

IV. DATASET

For Violation detection, a custom dataset is prepared from live footage captured and footage of violation from various online sources. The images extracted from the footages consists of both light and dense traffic conditions, to include diversity in data. The images extracted are manually annotated for various types of violations. A total of 3000 (train) and 1000 (test) images are labeled for violation.

V. PROPOSED METHODOLOGY

Step 1 - Initialization

- Import necessary libraries and functions.
- Define parameters.

Step 2 - Initialize Video Processing

Step 3 - Scan Every 180th frame

Step 4 - Motorcycle Detection

- Detects all two-wheelers/motorcycles in a frame.

Step 5 - Bounding Box Extraction:

- For each detected motorcycle, it extracts its bounding box.

Step 6 - Face and Helmet Detection:

- Detects faces and helmets within the cropped image.
- Counts the number of faces.

Step 7 - Helmet Violation:

- For each detected rider, check if a head is present within the bounding box.
- If a head is present, extract the head image and classify it using a pre-trained model to detect whether a helmet is present or not.
- Draw rectangles around heads.
- Label them with confidence scores based on helmet presence.

Step 8 - License Plate Detection

- If any violation is detected, it captures the license plate using the OCR.

Step 9 - Saving Violation Data:

- Saves the violated motorcycle image along with its license plate image and text.
- Records the list of violations for each images.

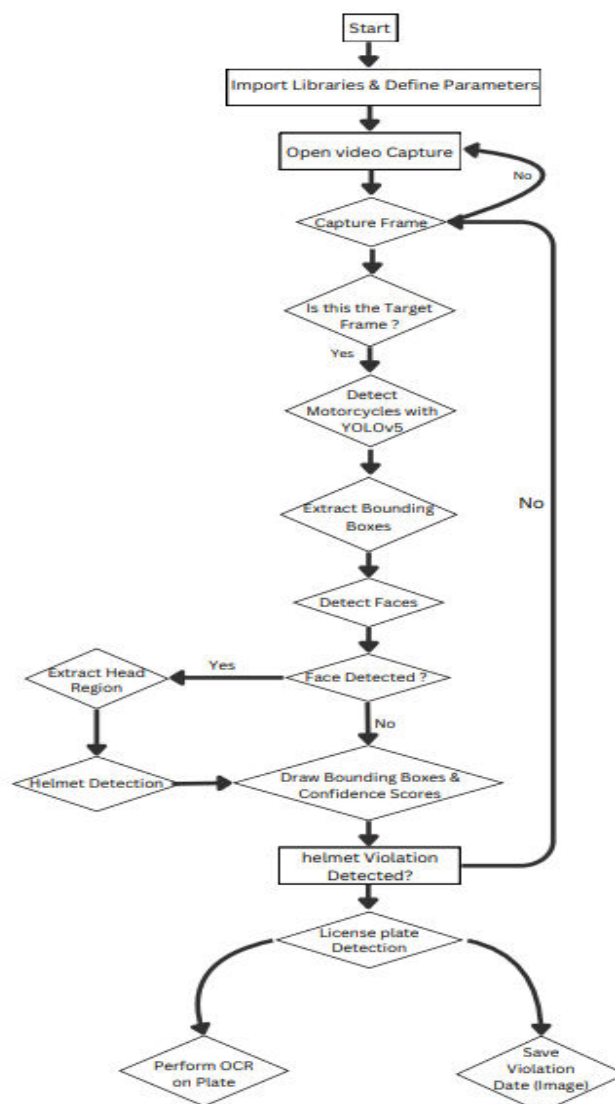


Figure 1: Data Flow Diagram



5.1. Data Collection

Gather a diverse dataset containing images and/or videos relevant to the task at hand, such as images/videos of riders with and without helmets, various head poses, different lighting conditions, and diverse backgrounds. Annotate the dataset to provide ground truth labels for object detection (bounding boxes for riders, heads, and number plates) and image classification (helmet presence/absence).

5.2. Data Preprocessing and Cleaning

Once we gathered a dataset from Kaggle, our next immediate step is to process that dataset. Data preprocessing is one of the foremost steps in deep learning because the accuracy and performance of the deep learning model will depend upon the quality of data that we are maintaining. Data pre-processing includes handling missing data values, removing duplicates, handling outliers etc. In our dataset after loading the dataset, we resize the image to a standard format i.e (224,224) and then, if the re-sized image contains the noise, we remove it by using de-noising techniques.

5.3. Splitting The Dataset

Using the Sklearn library, we divided the data into train and test subsets in this phase. The user may choose the split ratio, but most likely we will separate the dataset in a 75:25 ratio. This indicates that we will use 75% of the data for training and the leftover 25% for testing. The testing set is used to assess the deep learning model's success on fresh, untested data, while the training set is used to fit the model. In order to prevent overfitting the model to the training data, we must evaluate the model on a testing set to see how well it generalizes to new data. The model is more likely to perform well on fresh data if it does well on both the training and testing sets.

5.4. Building the Deep Learning Model

First load two YOLOv5 models. One is likely trained to identify motorcycles within video frames. The other performs a separate classification task - determining whether a helmet is present on a head detected within the motorcycle's bounding box.

The object detection function takes a frame from the video, feeds it through the YOLOv5 model, and obtains detections with bounding boxes and confidence scores. It then focuses on detections classified as motorcycles and draws bounding boxes around them on the frame.

When a motorcycle is identified, the code extracts the head region based on the motorcycle's bounding box. This extracted head image is then fed to the pre-trained helmet classification model, which predicts the presence or absence of a helmet and provides a confidence score for its prediction.

5.5. Calculate Performance Parameters

This step consists of calculating different performance measures such as recall, precision, accuracy etc the model with the most acceptable is the one which is having good accuracy and good recall and good precision is considered as a good model i.e The next step after implementing a deep learning algorithm is to find out how effective is the model based on metric and datasets. Different performance metrics are used to evaluate different deep Learning Algorithms. Example of a metric for evaluation of deep learning algorithms is precision, accuracy, recall, confusion matrix. Therefore, we see that different metrics are required to measure the efficiency of different algorithms, also depending upon the dataset at hand.

Validation Results:

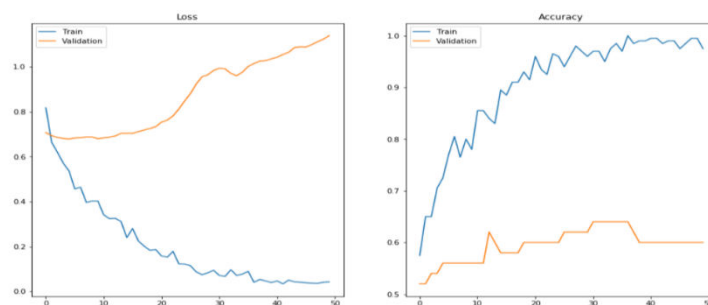


Figure 2: Validation graph

Performance Metrics:

Metrics	Value
Precision	0.910
Recall	0.853
mAP50	0.785

Table 1: Metrics

Precision: Measures the proportion of correctly identified vehicles out of all detections made by the model.

Recall: Measures the proportion of actual vehicles in the image that were correctly detected by the model.

Mean Average Precision (mAP): A comprehensive metric that considers both precision and recall at various Intersection over Union (IoU) thresholds.

Frames per Second (FPS): Evaluates the model's inference speed, crucial for real-time applications.

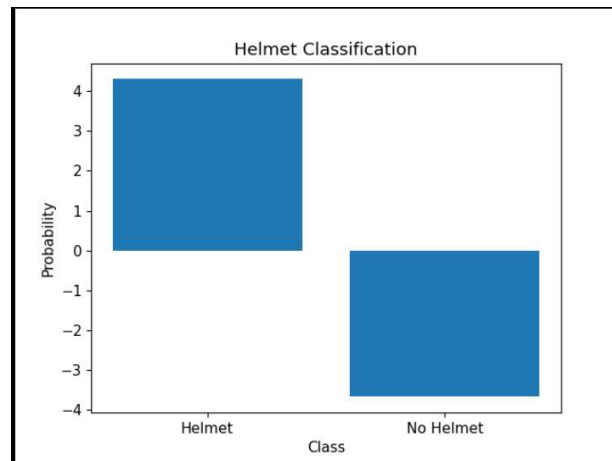


Figure 3 : Helmet Classification

VI. RESULTS

Our object detection system has aced its training! It can now pinpoint various objects within images, accurately identifying them based on the data it learned. This ability translates to real-time object detection in videos as well. By combining OpenCV and YOLOv5, the system efficiently processes video streams, providing valuable insights into what's happening on screen. This functionality is impressive in its adaptability, working across different settings and conditions. With its newfound prowess, the system empowers better decision-making by keeping you informed about your surroundings. This powerful combination of YOLOv5 and OpenCV offers a versatile solution, not just for traffic monitoring but also for security, surveillance, and beyond.

Table depicting the accuracy of YOLOv5 applied on datasets of sizes 3500 and 4000.

DATASET	TRAINING	TESTING	ACCURACY
3500	2625	875	88
4000	3000	1000	93

Table 2: Accuracy of YOLOv5

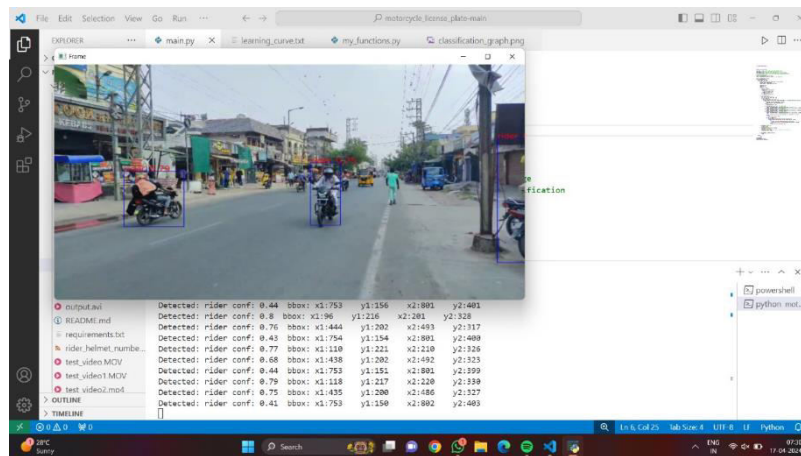


Figure 4: Frame

The image displays output from the algorithm, with bounding boxes drawn around detected objects labeled as "rider" along with confidence scores and coordinate values.



Figure 5: Result

Above image demonstrate the capabilities of computer vision algorithms to detect and identify various elements like people, vehicles, license plates, and potentially perform facial recognition within real-world scenes involving vehicles and traffic.



The system is designed for purposes such as traffic monitoring, law enforcement, or security applications where identifying and tracking vehicles and their occupants is relevant.

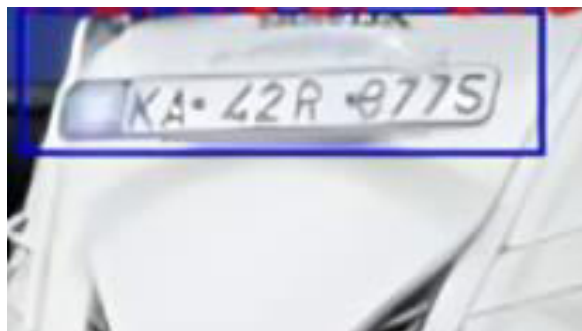


Figure 6: Number Plate

	A
1	Number Plate
2	KA42R0775
3	KA50L7261
4	TS32B0406
5	TS22B1234
6	AP37K5964
7	
8	
9	

Figure 7: OCR Output

Additionally, the validation process identifies and ensures the accurate detection and storage of number plates, providing functionality for tracking and storing number plate information in specified directions.

Along with the pictures, the system also saves the license plate numbers in a readable format. This is done by using a special technology called OCR (Optical Character Recognition) to automatically read the text from the images.

VII. CONCLUSION

In conclusion, this project goes beyond simply detecting helmets and license plates. Using high-resolution cameras and deep learning, it identifies safety violations in real-time, allowing authorities to take immediate action. Furthermore, Optical Character Recognition (OCR) extracts text from license plates, enabling cross-referencing with databases for vehicle information. This empowers law enforcement to identify stolen vehicles, track down offenders, and issue citations. Additionally, historical data analysis from license plates provides valuable insights into traffic patterns, aiding authorities in making informed decisions on regulations, infrastructure, and enforcement strategies. By combining real-time detection with OCR, this project significantly improves road safety and traffic management.

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