Automated Helmet Detection and E- Challan Generation using YOLOv8

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Abstract
One of the primary issues in the contemporary transport system is road safety, especially in those nations where two-wheelers are prevalent. Many accidents are caused by the riders not wearing helmets. The proposed research is an automated helmet detection system and e-challan generation system based on the YOLOv8 deep learning model. The system identifies the violation of helmet through traffic surveillance footage, and automatically identifies vehicle number plates by Optical Character Recognition (OCR). The information of the vehicle extracted is compared with a database to get the owner details and produce an electronic challan. The system suggested can minimize the effort of a manual system and enhance efficiency in the enforcement of traffic laws.

The suggested system will involve the use of YOLOv8 (You Only Look Once version 8) which is the latest and innovative object detection algorithm, to locate the motorcyclists and determine whether they wear helmets or not in real time. The model can identify the riders based on the presence of a helmet on them with a high degree of accuracy and speed by processing live CCTV footage or recorded video streams. The architectural design of YOLOv8 is lightweight and advanced and can be easily used in real-life scenarios, such as dynamic lighting, weather, and traffic conditions.

On detection of a violation, the vehicle number plate is captured by the system and the registration number is extracted with the help of Optical Character Recognition (OCR). This is then cross-tabulated with a vehicle registration database, where the owner will be automatically retrieved. A fine in the form of an e- challan (electronic fine) is then created and delivered to the vehicle owner in the registry via digital means of communication like SMS or email. This is an automated solution that will reduce the human factor in monitoring by traffic officers, minimize human error and ensure that traffic regulations are uniformly enforced. Furthermore, it offers a scalable and effective solution to smart city infrastructure through incorporation of artificial intelligence in traffic management systems.

Keywords: Helmet Detection, YOLOV8, Computer Vision, OCR, E-Challan System, Traffic Monitoring.

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Introduction

One of the most significant issues in the contemporary society and particularly the developing countries is road safety particularly in the developing nations where two-wheelers are the greatest percentage of the daily traffic. Although there are stringent laws to use helmets, the level of non-compliance is alarming, resulting in more deaths and head injuries in case of road accidents.

Helmet laws are not efficient to be enforced manually and are subject to human error and need constant supervision by traffic officers [1][6] Artificial Intelligence (AI) and Computer Vision integration into the traffic management systems can be a solution to address these difficulties. The given project is aimed at creating an Automated Helmet Detection and E-Challan Generation System based on YOLOv8 (You Only Look Once, version 8) which is the latest deep learning model that can be used to detect objects in real-time. The system automatically identifies the motorcyclists on video feeds, determines whether they have helmets and records the vehicle number plate to process further. In the event of a violation, an e-challan (electronic fine) is automatically issued and dispatched to the registered vehicle owner via digital communication channels, e.g. SMS or email.

This AI-based method will reduce human interference, increase the efficiency of law enforcement and is helping to develop smart transportation systems, which will eventually make the roads safer and ensure that people drive responsibly.

In this project, an intelligent helmet detection system is proposed based on the YOLOv8, which detects helmet-less riders automatically and issues e-challans

Problem Statement

Despite tough helmet laws, a number of riders are not going to follow safety laws. It is challenging to monitor helmet violations manually as the traffic police cannot monitor all roads at the same time.

Lack of automated surveillance causes slow detection of breaches and lack of effective implementation of the traffic regulations.

The proposed project is aimed at solving these problems by suggesting an automated system that will be able to identify helmet violations and issue e-challans automatically.

Objectives of the Study

The primary goals of the study are:

- Build a real-time helmets detector with YOLOv8.
- Read vehicle number plates and OCR registration numbers.
- Get the owner of vehicle details out of a database.
- Create auto generated traffic violation issuance of electronic challengans.
- Enhance road safety and efficiency of traffic monitoring.

Literature Review

Review of Existing Helmet Detection Systems

Over the past few years, the researchers concentrated on the creation of automated methods to identify helmet violation cases with the help of computer vision and machine learning. The first methods used conventional image-processing techniques which include edge-detection, color-segmentation, and Histogram of Oriented Gradients (HOG) features to detect motorcycles and helmets. In recent years, scientists have concentrated on automated systems to identify helmet violations based on the traffic surveillance cameras and computer vision and machine learning methods. Original methods were based on conventional image-processing algorithms like edge detection, color segmentation, and Histogram of Oriented Gradients (HOG) features to detect motorcycles and helmet. Such methods tried to recognize the shapes and colors of the helmet of traffic photos taken by cameras.

But, conventional image-processing algorithms still had a number of constraints in their application to real-world traffic. The accuracy of such systems was usually diminished by changes in lighting conditions, the use of various colors of helmets, the complexity of the background, and camera angles. Therefore, a lot of the initial helmet detection systems lacked in their ability to deliver dependable data in crowded urban traffic situations.[2][3]

With the development of deep learning technologies, scientists started to employ Convolutional Neural Networks (CNNs) and object detector networks like Faster R-CNN, SSD, and YOLO to enhance the accuracy of detection. These models can acquire complex visual patterns on large scale datasets and can successfully detect objects in real time.

The main limitations identified in existing systems include:

- The poor light, shadow, or traffic conditions detectability.
- Traditional CNN architectures are expensive to compute, hence challenging to deploy in real-time. Absence of the connection between helmet detection and e-challan systems. Reliance on a manual check, which results in time wastage and human mistakes.
- Poor flexibility to various environmental factors and camera angles.
- These problems make existing techniques less viable and efficient in practice in the real-world traffic setting.

Proposed System

The suggested system combines the methods of deep learning and computer vision to automatic detection of helmet violations.

The system intercepts real-time video feeds of the CCTV cameras that are installed at crossing points of traffic. The YOLOv8 model is used to process video frames to identify motorcycles, riders, and helmets[13].

On detection of a rider who is not wearing a helmet, the system records the vehicle number plate and reads off the registration number through OCR.

Records the images and metadata of the detected violations in a central database to store them.

Compares the data obtained with the vehicle registration database to access data about the owner.

System Architecture

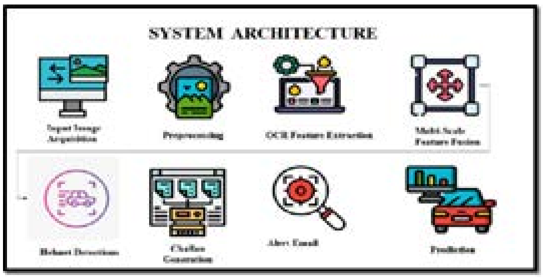

Figure 1 Workflow of Helmet Detection

The following are the components of the system architecture:

- Image Acquisition Module
- Preprocessing Module
- Object Detection Module
- Helmet Detection Module

Methodology

Image Acquisition Module

The image acquisition module will be in charge of capturing images or video frames of the traffic surveillance cameras. Such cameras are normally found at road intersections or highways to check road activity.

The frames captured are transmitted to the processing module where the system processes the visual information to identify vehicles and riders.

Preprocessing Module

The input images are subjected to a few preprocessing steps before using deep learning models. These measures contribute to enhancing the quality of the images and raising the accuracy of detection

The preprocessing methods are:

- Image resizing
- Noise reduction
- Image normalization
- Data augmentation

The processes will make the images appropriate in training and testing the deep learning model.

Object Detection Module

Object detection module recognizes the objects in the image. The object detection algorithm, which is applied in this project, is the YOLOv8.

YOLOv8 breaks the image into grids and forecasts bounding boxes of objects. The information in each bounding box will be the object class and probability score.

The object detection module identifies

- Motorcycle
- Rider
- Helmet

Helmet Detection Module

After measuring the rider, the system examines the presence of a helmet on the rider. The helmet detection module identifies the identified rider in two groups:

- Helmet
- No Helmet

In case the rider has not put on a helmet, the system will record it as a traffic offence and then move to the next level of number plate recognition.

License Plate Recognition Module

Once a helmet violation has been detected, the system takes the image of the motorcycle and identifies the vehicle number plate. The number plate region, which has been detected, is then subjected to the Optical Character Recognition (OCR) to remove the characters on the plate.

The number plate data obtained is extracted and the vehicle owner is identified using the traffic authority database.

E-Challan Generation Module

The last module of the system will produce an electronic challan. After the violation has been verified and the vehicle number has been obtained, a digital record of the penalty is automatically developed by the system. [8][9].

The e-challan includes the following information:

- Vehicle registration number
- Date and time of violation
- Location of violation
- Type of violation
- Fine amount

The challan may be communicated to the vehicle owner via SMS, email or traffic authority portals.

High-Level System Architecture

The general structure of the proposed system will be one that will incorporate computer vision, deep learning, and database management to create a well-integrated system. Figure 4.1 shows the high-level workflow of the system that can be generally broken down into three stages

1. Detection Phase - Identifying riders and identifying the presence of a helmet within the YOLOv8.
2. Recognition Phase - Determining the number plate and vehicle information through OCR.
3. Enforcement Phase- Automatically generating an e-challan and transmitting it to violator.

Input and Preprocessing

The system takes input in form of real-time CCTV cameras or video feeds that are pre-recorded. Frame (video) is taken at a given time interval to provide computational efficiency. Image resizing, noise reduction, and brightness normalization are also preprocessing steps meant to enhance the accuracy of detection particularly in high glare or low-light situations.

Detection and Analysis

Each frame is processed by the YOLOv8 model to identify objects of interest, i.e. motorcycles, riders and helmets. The system will check the presence of a helmet on a detected rider. When a violation (no helmet detected) is detected, the related frame is sent to the number plate detection module.

Data Flow

Once a violation is detected the number plate is localized and extracted. OCR is used to transform the text into machine readable characters. The identified registration number is then compared with the Regional Transport Office (RTO) or a local database to retrieve the owner of the vehicle. A e-challan is subsequently created and sent to the violator through digital communications.

This modular architecture is scalable, real-time, and can be easily integrated with existing traffic management systems.

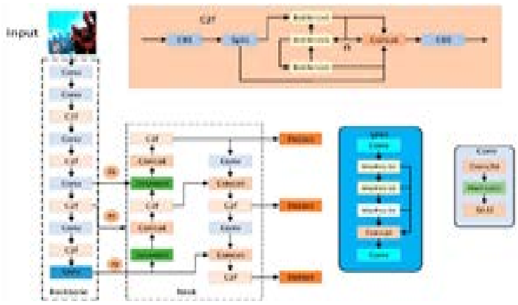

Figure 2 Helmet Detection using YOLOv8

Overview of YOLOv8

- YOLOv8 (You Only Look Once, Version 8) is the recent addition to the YOLO family of object detector algorithms created by Ultralytics. It proposes anchor-free, better backbone structure, and more powerful non-max suppression (NMS). The model is more accurate yet with high frame-per-second (FPS) processing speeds and this is the best to use in real-time surveillance..
- YOLOv8 is a single-stage detector in contrast to two-stage detectors, e.g., Faster R-CNN, where localization and classification of objects are performed jointly. This significantly decreases the computation time and renders YOLOv8 to live video processing

Dataset Preparation

The dataset to be used to detect the helmet will be annotated images of two-wheeler riders with and without helmets. Photos are gathered in both the open sources and the local traffic cameras. The data is classified with three key categories:

- Motorcycle

- Person
- Helmet

Data augmentation methods like rotation, flipping, scaling, brightness change and noise injection are used to augment model generalization in varying weather and light conditions..

Training Process

YOLOv8 model is trained in the prepared dataset utilizing transfer learning. The data on the pre-trained YOLOv8 (trained on the COCO dataset) model is fine-tuned using custom helmet data. The Adam optimizer, a learning rate of 0.001 and batch normalization are applied to the training process to enhance the convergence and avoid overfitting. The model is trained until the average (mAP) reaches a stable value.

Optical Character Recognition (OCR)

Figure 3 Optical Character Recognition (OCR)

Overview

The conversion of text images (in this case vehicle number plates) into machine readable characters is known as Optical Character Recognition (OCR). OCR is used as the interface between the visual recognition and the database search in this project.

OCR Framework

The OCR module is based on EasyOCR which is a Python library that utilizes deep learning models (CNN + RNN architecture) to extract text accurately. EasyOCR is preferred to the classic tools such as Tesseract because it has superiority in images with noise, or low-resolution images.

Working Principle

1. Input: The input to the OCR model is the cropped number plate image of the detection module.
2. The OCR model identifies and breaks characters by the CNN-based feature extraction.
3. RNN or LSTM layers are used to predict sequential text.
4. Post-processing is used to eliminate undesired characters or noise.

E-Challan Generation and Notification

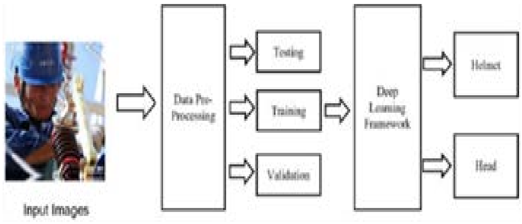

Figure 4 E-Challan Generation and Notification

Once verified, the system will automatically create an e-challan that includes the following details: [8][9].

- Vehicle Number
- Owner Name
- Date, Time, and Location of Violation
- Violation Type (Helmet not worn)
- Fine Amount

Captured Image of the Violation

This e-challan is created in standardized form of digital format (PDF/HTML) and saved in the database of the traffic authority.

It is then correlated with the respective violation record so that it can be easily retrieved and used in future. The system also incorporates SMS and email gateway to automatically inform the vehicle owner about the offense and offer a secure payment link to pay fines.

E-challans are allocated identification numbers to be able to trace them and to avoid duplication. The produced challengans are signed and their time is stamped in order to ensure authenticity and integrity.

Moreover, the system keeps detailed records of all the transactions made and this keeps the issuance of penalties transparent and accountable..

Notification System

- After e-challan is created, the system will send digital notification to the registered vehicle owner through:

- SMS, with payment link and number of the challan.
- Email, and attach challenging evidence, including challan and images.

Advantages

Automation of e-challan process has various advantages:

- Removes the use of manual labor by traffic personnel.
- Provides uniformity and quality of violation records.
- Minimizes human error and corruption.
- Allows traffic to be enforced on a large scale and in real-time.

Results and Discussion

This part will examine the performance, accuracy and effectiveness of the proposed automated system of helmet detection and e-challan generation system, through experimental assessment and experimentation through traffic video data. The system was tested in various traffic conditions to assess the ability of the system in identifying helmet offences and retrieving vehicle number plates correctly.

Helmet Detection Accuracy Analysis

The helmet detector was tested on traffic pictures and video frames with helmeted and unhelmeted riders. The labeled datasets comprised of motorcycles, riders, and helmets which were used to train the YOLOv8 object detection model. The model was subsequently tested on the trained model to evaluate its capability of correctly identifying helmet violations in actual traffic conditions.

Results Observed

- The proposed Automated Helmet Detection and E-Challan Generation system was tested on the dataset of traffic images and video frames with motorcyclists with and without helmets. The YOLOv8 object detection model was trained to detect three major items, namely motorcycle, rider, and helmet. The model was tested on different scenarios in traffic after training.
- To examine its accuracy and efficiency.
- The system identifies motorcycles and riders on video images and identifies whether a rider has a helmet or not. In case of a rider with no helmet, the vehicle number plate area is captured by the system on the frame. The image is then processed using the methods of Optical Character Recognition (OCR) to obtain the vehicle registration number.
- The system recognizes the motorcycles and the riders on the video images and determines whether a rider is wearing a helmet or not. The vehicle number plate section of the frame is recorded by the system in case of a rider without a helmet. The photo is then subjected to the Optical Character Recognition (OCR) techniques to get the vehicle registration number.
- Experimental findings indicate that the YOLOv8-based detection model is highly accurate in detecting non-helmeted riders and that it can be effectively used in changing lighting and traffic conditions. The number plate recognition and automatic generation of e-challan also makes the system more efficient in real-time monitoring of the traffic.

Detection Performance Analysis

Measures like Precision, Recall and Mean Average Precision (mAP) were taken to measure the performance of the model. Precision measures the rate at which the correct number of helmet violation are identified out of the total number of detected helmet violations whereas recall measures how effectively the system identifies all the actual violations of helmets in the dataset. Mean Average Precision (mAP) is a general measure of the performance of the object detection model, as it takes into account precision and recall..

The results of the classification of the helmets and non-helmets were also analyzed using a confusion matrix. The findings reveal that the YOLOv8 model is highly accurate in the detection of riders and is capable of identifying helmetless riders in different traffic conditions. The model is effective even in moderate changes in lighting and in complicated traffic conditions, which proves the applicability of the model in real-time traffic monitoring applications.

Performance and Responsiveness Analysis

The Automated Helmet Detection and E-Challan Generation system proposed was tested on several traffic video datasets taken in the varying environmental settings. The system was tested to examine its performance, processing speed and detection of helmet violations in real-time traffic environment.

Performance Metrics

The system performance was measured in terms of the following metrics:

1. Frame Processing Time: Frame Processing Time- The system can process every frame of the video in a brief period of time, which allows it to detect in real-time.
2. Accuracy of Helmet Detection: The YOLOv8 model is able to detect helmeted and unhelmeted riders in traffic images.
3. Number Plate Recognition Time: The Optical Character Recognition (OCR) module reads the vehicle registration number in a few seconds.
4. E-Challan Generation Response: After a violation is identified, the system will automatically fetch the vehicle information and produce an electronic challan virtually immediately.

The experiments indicate that the suggested system can be effectively employed in real-time monitoring of traffic and automated policing without any serious delays.

Comparative Analysis with Existing Systems

The proposed system has a number of benefits over the conventional traffic monitoring systems which depend on manual monitoring by the traffic police.

1. Automated Helmet Violation Detection: The system will use the YOLOv8 deep learning model to automatically detect helmetless riders.
2. Real-Time Monitoring: Construction of a constant monitoring using CCTV cameras allows detection of traffic violations in real-time.
3. Automatic Number Plate Recognition: The system incorporates OCR technology to automatically read vehicle registration numbers.
4. Automated E-Challan Generation: Fines are automatically created and no manual effort is needed by the traffic authorities.

Conventional methods of monitoring are time consuming, labor intensive and subject to human error as compared to the proposed system which is more reliable, efficient and fast when it comes to implementing the helmet laws.

Advantages of the Proposed System

- Enhances road safety by locating the helmet offenses automatically.
- Less manual work by the traffic enforcement authorities.
- Offers real-time traffic monitoring, based on AI-based detection models.
- Ensures proper registration number identification of vehicles.
- Enables effective and transparency e-challan generation.
- Favors the creation of smart traffic management solutions.

Future Work

The proposed automated helmet detection and echallan generation system can be enhanced in future to increase its functionality and relevance in the real world traffic condition. The integration of more complex deep learning models and larger datasets to enhance detection accuracy in challenging conditions (low light, heavy traffic, etc.) may be regarded as one of the possible improvements.

It is also possible to expand the system to identify other traffic offenses that include triple riding, jumping the lights, over-speeding, and use of cell phones when driving. These features would enable the system to be a complete traffic monitoring system.

The other possible improvement would be the possibility to connect the system to smart city infrastructure and IoT-powered traffic cameras, which would allow providing scale-based real-time monitoring in multiple points. The system may also be linked to government traffic management databases and mobile apps, which will enable owners of vehicles to get e-challan notifications and pay online easily.

These would add to the creation of smart transportation systems and even enhance more automated traffic law enforcement.

Conclusion

The e-challan generation and automated helmet detection system offers an effective way of tracking down the traffic offenders.

With the help of the integration of YOLOv8, OCR, and database technologies, it is possible to detect and automatically generate penalties.

The suggested system is a contribution towards enhanced road safety and the new intelligent transportation systems.

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