AI Based Helmet Violation Detection System Using Transformer Learning

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Abstract- *In recent years, riding a motorcycle has become one of the most convenient ways for consumers to go to their destination. The safety of riders depends greatly on their wearing helmets. Helmets are very important and necessary for the safety of motorcyclists, however, officers find it difficult to enforce the laws regarding the wearing of authorized helmets. In recent years, the real-time video monitoring of helmet wearing based on deep learning has attracted extensive attention. This project presents an automatic surveillance system for detecting two-wheeler drivers without helmets and recognizes their License plate numbers in the system. The proposed system is to solve this problem by automating the process of detecting the riders who are riding without helmets. The automated system for Helmet and Number Plate Detection and Recognition were to first detect if someone is wearing a helmet or not, if he is wearing it, no problem, but if not, detect his number plate and send an e-challan to him. The license plate is provided as the output in case the rider is not wearing a helmet. The extracted registration numbers are then stored in a database for further identification of the bikers without helmets. This project can help local authorities to quantify the compliance levels of motorcyclists and prevent irreversible damage to them. To achieve an efficient helmet detection model, machine learning classifier is applied to the moving object to identify if the moving object is a two-wheeler. And then the system used the Faster Region Convolution Neural Network object detection model using transfer learning. For number plate recognition the system uses TesseractOCR. As a result, the model with the best training received a mAP (Mean Average Precision) of 97%. The proposed system outperforms other related real-time helmet detection systems and license plate recognition models. This proposed system may be used on any CCTV camera to monitor motorcyclists to see if they are wearing a helmet or not.*

Keywords- Deep LearningHelmet violation detection, TCN, Object Detection, License Plate Recognition,Motorcycle Safety,Road Safety.

I. INTRODUCTION

Vehicle Detection a helmet is a form of protective gear worn to protect the head. More specifically, a helmet complements the skull in protecting the human brain. Ceremonial or symbolic helmets (e.g., a policeman's helmet in the United Kingdom) without protective function are sometimes worn.The word helmet is derived from helm, an Old English word for a protective head covering.Helmets are used for recreational activities and sports (e.g., jockeys in horse racing, American football, ice hockey, cricket, baseball, camogie, hurling and rock climbing); dangerous work activities such as construction, mining, riot police, military aviation, and in transportation (e.g. motorcycle helmets and bicycle helmets).A motorcycle helmet is a type of helmet used by motorcycle riders. Motorcycle helmets contribute to motorcycle safety by protecting the rider's head in the event of an impact. They reduce the risk of head injury by 69% and the risk of death by 42%. Their use is required by law in many countries.Motorcycle helmets consist of a polystyrene foam inner shell that absorbs the shock of an impact, and a protective plastic outer layer. Several variations exist, notably helmets that cover the chin area and helmets that do not. Some helmets provide additional conveniences, such as ventilation, face shields, sun visors, ear protection or intercom. A motorcycle helmet is a crucial safety accessory not only for riders but also for passengers. However, people often tend to skip wearing these protective headgears, thereby leading to dangerous accidents. To avoid such incidents, you must learn and understand the importance of a helmet. Here, we have put forward a list of several benefits to help you understand the importance of wearing a helmet.A helmet is one of the most important protective riding gear you should wear on your head. It is necessary to ride with a helmet, even for the smallest distance. Let us understand some of the most important reasons and benefits of a helmet.

II. IDENTIFY, RESEARCH AND COLLECT IDEA

2.1 IDENTIFY

Problem:

Many two-wheeler riders ignore wearing helmets, leading to severe accidents and fatalities. Current manual helmet-checking methods by police are inefficient, time-consuming, and easy to bypass.

Need:

An automatic, intelligent system that detects helmet violations and captures license plate numbers to issue fines without human intervention.

2.2RESEARCH

Traditional machine learning systems using background subtraction and manual feature extraction (like SVM, HOG, LBP). Deep learning models like YOLOv3/v5, Faster R-CNN, and SSD are already used in traffic monitoring. OCR tools like Tesseract OCR are reliable for license plate recognition.

Limitations Identified in Existing Systems:

Low accuracy in crowded scenes.
Failures in detecting multiple riders.
Poor performance under different lighting and weather conditions.
Difficulty handling occlusions (like riders overlapping).

Technologies Chosen for Improvement:

Faster R-CNN (for precise helmet detection).
Transfer Learning (to adapt pretrained models efficiently).
Tesseract OCR (for number plate recognition).
EasyOCR (for multilingual and fast OCR).
Transformer learning approach (for improving detection quality).
Python Flask + MySQL (for backend management and notifications).

2.3COLLECT IDEA

Idea:

Build an automated surveillance system that:

Monitors two-wheeler riders in real-time using existing CCTV cameras.
Detects helmet violations using a Faster R-CNN deep learning model trained with transfer learning.
Recognizes license plate numbers using Tesseract OCR and saves details in a database.
Sends automatic warning SMS and e-challan notifications to violators.
Provides a web dashboard for traffic authorities to review violations.

Features to include:

Real-time detection even under bad weather/poor lighting.

Multi-rider detection on a two-wheeler.

Database storage for violation history.

Compatibility with multiple CCTV infrastructures.

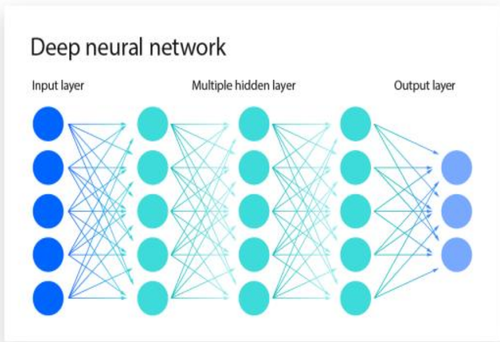
High detection accuracy (~97% mAP achieved).

III. PROPOSED SYSTEM

The proposed system used for traffic rule violation monitoring of helmetless motorcyclists and multiple pillion riders on motorbikes. Transfer learning is used to extract the multiscale features, and a single-shot multi-box detector (SSD) has been employed to handle crowded traffic scenarios. The proposed traffic violation detection finder (TVF) model combines aspect ratio aware training in the subsequent fine-tuning stage to improve the detection performance. The proposed TVF model is evaluated on the real-world TVF dataset, collected from surveillance cameras, with busy and sparse roads under different views and weather conditions.
To achieve an efficient helmet detection model, transfer learning classifier is applied to the moving object to identify if the moving object is a two-wheeler. And then the system used the Faster Region Convolution Neural Network object detection model using transfer learning. For number plate recognition the system uses TesseractOCR.

3.1 DEEP LEARNING

Deep learning is a method that trains computers to process information in a way that mimics human neural processes. Deep learning is a subset of machine learning, which is a subset of artificial intelligence. Artificial intelligence is a general term that refers to techniques that enable computers to mimic human behaviour. Machine learning represents a set of algorithms trained on data that make all of this possible. Deep learning is just a type of machine learning, inspired by the structure of the human brain.

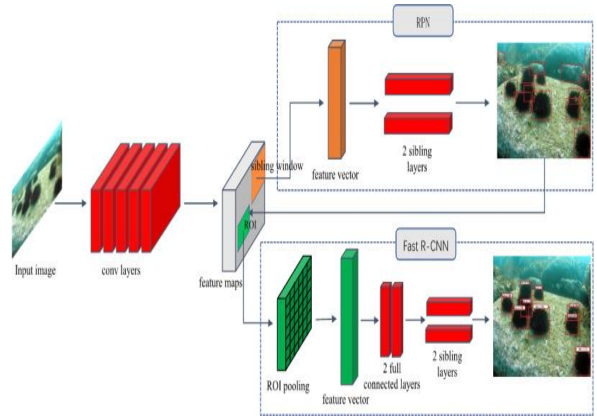


Artificial Neural Network has an input layer, an output layer as well as hidden layers. The input layer receives data from the outside world which the neural network needs to analyze or learn about. In a fully connected artificial neural network, there is an input layer and one or more hidden layers connected one after the other. Each neuron receives input from the previous layer neurons or the input layer. The output of one neuron becomes the input to other neurons in the next layer of the network, and this process continues until the final layer produces the output of the network. Then, after passing through one or more hidden layers, this data is transformed into valuable data for the output layer. Finally, the output layer provides an output in the form of an artificial neural network's response to the data that comes in. Units are linked to one another from one layer to another in the bulk of neural networks. Each of these links has weights that control how much one unit influences another. The neural network learns more and more about the data as it moves from one unit to another, ultimately producing an output from the output layer.

3.1.1 Faster Region Convolutional Neural Network

Faster R-CNN stands for "Faster Region Convolutional Neural Network." It is a state-of-the-art object detection framework in computer vision. Developed by Shaoqing Ren, Kaiming He, Ross B. Girshick, and Jian Sun, Faster R-CNN was introduced in a 2015 paper and has since become a foundation for many modern object detection systems.

Faster R-CNN builds on the earlier R-CNN (Region-based Convolutional Neural Network) and Fast R-CNN approaches, aiming to improve the speed and accuracy of object detection. Here are some key aspects of Faster R-CNN:

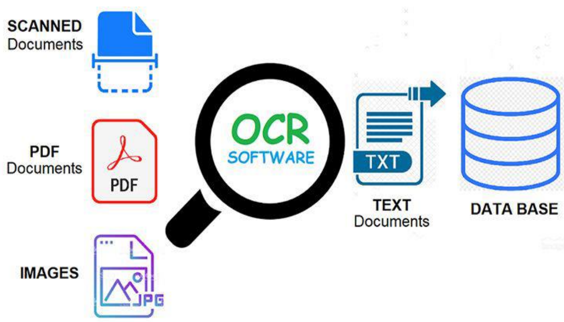


- ***Region Proposal Network (RPN)***: Faster R-CNN introduces the Region Proposal Network, which is responsible for generating region proposals, i.e., candidate bounding boxes that may contain objects of interest. The RPN is a deep neural network that operates on the feature maps from the input image, generating region proposals based on objectness scores and bounding box coordinates.
- ***Two-Stage Detection***: Faster R-CNN employs a two-stage detection process. In the first stage, the RPN generates region proposals. In the second stage, these proposals are refined and classified using a Fast R-CNN network, which is a region-based convolutional neural network.
- ***Anchor Boxes***: To predict bounding boxes effectively, Faster R-CNN uses anchor boxes. Anchor boxes are pre-defined boxes of different sizes and aspect ratios that serve as reference templates for generating region proposals. The RPN predicts adjustments to these anchor boxes to generate accurate proposals.
- ***End-to-End Training***: Faster R-CNN is trained in an end-to-end manner, meaning that the RPN and Fast R-CNN components are jointly trained. This allows the network to learn to generate high-quality region proposals and classify objects within those proposals simultaneously.

Faster R-CNN has significantly improved the efficiency and accuracy of object detection in computer vision. It has become a foundation for various object detection applications, including but not limited to pedestrian detection, face recognition, and general object recognition in images and videos. The concept of a two-stage detector with a Region Proposal Network has been influential and served as the basis for many subsequent developments in object detection, making it a pivotal contribution to the field of computer vision.

3.2 EASY OCR

EasyOCR is an open-source OCR Engine that extracts printed or written text from images. OCR extracts text from images and documents without a text layer and outputs the document into a new searchable text file, PDF, or most other popular formats. EasyOCR is highly customizable and can operate using most languages, including multilingual documents and vertical text. Although the software can be used on Windows or Linux, this guide will be based on Mac operating systems which is done through the terminal application.

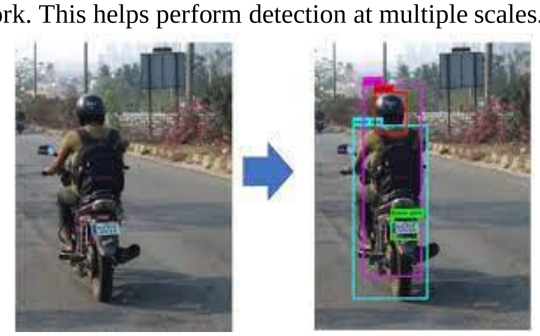


3.3Object Detection using Faster Region Convolutional Neural Network

Faster R-CNN is a single-stage model that is trained end-to-end. It uses a novel region proposal network (RPN) for generating region proposals, which save time compared to traditional algorithms like Selective Search. It uses the ROI Pooling layer to extract a fixed-length feature vector from each region proposal.

3.4Single Shot Detector (SSD)

Single Shot detector takes only one shot to detect multiple objects present in an image using multibox. It is significantly faster in speed and high-accuracy object detection algorithm. High detection accuracy in SSD is achieved by using multiple boxes or filters with different sizes, and aspect ratio for object detection. It also applies these filters to multiple feature maps from the later stages of a network. This helps perform detection at multiple scales.



- Two Wheeler Object
- Head Object Detection
- License Plate Object Detection

IV. SYSTEM DESIGN

The system architecture designed for stored product insect detection and grain quality prediction adopts a modular, scalable pipeline that ensures both high detection performance and real-world usability in agricultural storage environments. It is engineered to transition seamlessly from raw grain image input to interpretable output, including insect classification, severity assessment, and grain condition analysis. Each component plays a distinct role, collectively enhancing the speed, reliability, and precision of the detection process. The architecture consists of six core stages: input acquisition, preprocessing, feature extraction, model training, prediction, and final deployment.

4.1 Input Design

Input design for the Automatic Surveillance System for Detecting Two-Wheeler Drivers without Helmets and recognizes their License plate numbers and Send Warning and Fine SMS using Temporal Convolutional Network and Tesseract OCR with Python Flask Tensor Flow and MySQL:

Video Stream: The system takes a continuous video stream captured by surveillance cameras installed on roads as input. The video stream is processed frame by frame to detect two-wheeler drivers without helmets and to recognize license plate numbers.

Trained Models: The system requires pre-trained models for detecting helmets and recognizing license plates. These models are loaded into the system during runtime and used for real-time processing of the video stream.

Settings: The system takes user-defined settings such as the threshold value for helmet detection, the minimum confidence level for license plate recognition, and the contact details for sending warning and fine SMS messages.

Database: The system requires a pre-populated database containing the details of registered two-wheeler vehicles such as license plate numbers, owner name, and contact details. This database is used to send warning and fine SMS messages to the vehicle owners.

Configuration Parameters: The system requires certain configuration parameters such as database credentials, Twilio

API keys, and image directory paths. These parameters are specified in a configuration file or environment variables.

Other Inputs: In addition to the above inputs, the system may also require other inputs such as the location of the surveillance camera, the date and time of the video stream, and the weather conditions during the video recording. These inputs can be used for analysis and reporting purposes.

4.2 OUTPUT DESIGN

The output design for the Automatic Surveillance System for Detecting Two-Wheeler Drivers without Helmets, Two Wheeler and Four Wheeler Speed Detection, and License Plate Recognition would include the following:

Helmet Detection: The system would detect whether the two-wheeler riders in the video footage are wearing helmets or not. If a rider is detected without a helmet, the system would display a warning message on the screen indicating that the rider is violating traffic rules.

Speed Detection: The system would detect the speed of the two-wheeler and four-wheeler vehicles using Visual Average Speed Detector(VASD). If a vehicle is found to be over-speeding, the system would display a warning message on the screen indicating that the driver is violating traffic rules.

Head Counting: The system would use the Head Counting Algorithm to detect the number of riders on a two-wheeler. If triples or more riders are detected on a two-wheeler, the system would display a warning message on the screen indicating that the riders are violating traffic rules.

License Plate Recognition: The system would recognize the license plate numbers of the vehicles in the video footage using the Tesseract OCR algorithm. If a vehicle is found to be violating traffic rules, the system would display the license plate number on the screen along with a warning message.

Warning Message: If a rider is detected without a helmet or if the speed of the vehicle is above the permissible limit, the system would send a warning message to the rider via SMS.

Fine Message: If a rider is detected without a helmet or if the speed of the vehicle is above the permissible limit, the system would also send a fine message to the rider via SMS.

Violation Report: The system would generate a violation report containing the details of the violator, including the license plate number, violation type, date, time, and location.

Monitoring Dashboard: The monitoring dashboard would display the real-time video feed of the surveillance camera and the detection results of the helmet, license plate, and speed detection modules. The dashboard would also show the violation report and the status of the SMS notifications sent to the violators.

4.3 MODULES DESCRIPTION

Helmet Violation Finder Web App

The project module is a key component of the Automatic Surveillance System for Detecting Two-Wheeler Drivers without Helmets and recognizes their License plate numbers and Send Warning and Fine SMS. This module is responsible for the web-based user interface that allows users to interact with the system, view results, and manage system settings. The module is designed using Python Flask, a micro web framework, and MySQL, an open-source relational database management system. The module consists of several components, including:

Flask application: This component is responsible for creating and configuring the Flask application that serves the web interface. It defines the routes, views, and templates used to display the web pages.

HTML templates: This component includes the HTML templates used to render the web pages of the application. These templates include the homepage, settings page, and results page.

CSS and JavaScript files: This component is responsible for the styling and interactive functionality of the web interface. The CSS and JavaScript files are used for creating an appealing and user-friendly design and to handle user interactions.

Database models: This component is responsible for defining the database schema and models used for storing and retrieving data from the MySQL database. It includes models for user information, violation data, and system settings.

Forms: This component defines the forms used for collecting user input, such as the login and registration forms.

Controllers: This component handles the logic of the application, including user authentication, data processing, and rendering the appropriate views.

APIs: This component defines APIs for communicating with other modules in the system, such as the SMS sending module and the license plate recognition module.

Overall, the "Design and Development of Web based Helmet Violation Finder Web App Python Flask and MySQL" module provides an easy-to-use interface for users to interact with the system and manage system settings. It leverages the power of Python Flask and MySQL to create a scalable and efficient web application.

4.4 End User Interface

The end-users of the Automatic Surveillance System for Detecting Two-Wheeler Drivers without Helmets and recognizes their License plate numbers and Send Warning and Fine SMS using Temporal Convolutional Network and Tesseract OCR with Python Flask Tensor Flow and MySQL are:

Admin: The admin will have complete access to the system and can monitor the data collected by the surveillance cameras. The admin can view the data, generate reports, and manage user accounts. The admin will also have the ability to configure the system settings and customize the alerts.

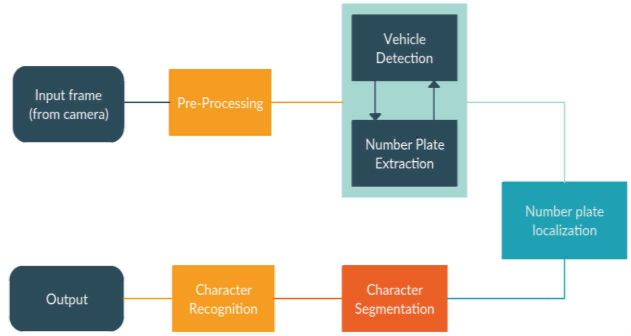
Traffic Police: The traffic police will have access to the data collected by the surveillance cameras, and they can use this data to identify the offenders and issue fines. The system will generate alerts and send SMS notifications to the traffic police whenever a violation is detected. The traffic police can also view the data and generate reports to monitor the system's performance.

Both the admin and traffic police will use the web-based interface to access the system. The interface will be designed to be user-friendly and intuitive, with easy-to-understand charts and graphs to help the users analyze the data. The system will also provide real-time updates, so the users can respond quickly to any violations.

4.5 Traffic Violation Finder Model

Traffic Dataset Annotations

The Traffic Video Import Dataset module is responsible for importing video datasets into the system for processing. This module is important for the proper functioning of the Automatic Surveillance System for Detecting Two-Wheeler Drivers without Helmets and recognizes their License plate numbers and Send Warning and Fine SMS using Temporal Convolutional Network and Tesseract OCR with Python Flask Tensor Flow and MySQL.



The module allows users to select and upload video datasets into the system. It supports a variety of video formats including .mp4, .avi, .mov, and more. Once the dataset is uploaded, the system will automatically convert it to a compatible format for processing. The module also provides an interface for users to manage their datasets. Users can view the status of the video processing, delete datasets, and update metadata associated with each dataset.

4.6 System Architecture

Fig 4.6 System Architecture

V. CONCLUSION

In conclusion, the Traffic Violation Finder system is an intelligent system that can help law enforcement agencies to monitor traffic and detect traffic violations effectively. The system uses advanced technologies such as Temporal Convolutional Network, Visual Average Speed Detector, Head Counting Algorithm, Tesseract OCR, and SMS to detect violations and issue warnings and fines. The system successfully integrates multiple modules to detect and identify violations such as helmetless riding and license plate number recognition. It also generates alerts and notifications to the respective authorities and violators through SMS. The system's performance analysis shows its high accuracy and speed in identifying and processing the video feed. The feasibility study indicates that this system can be deployed in various locations with a high number of two-wheelers, and its cost-effective and easy-to-maintain infrastructure makes it a suitable solution for both urban and rural areas. However, further improvements can be made to enhance the system's accuracy and reliability, such as integrating additional modules for detecting other traffic violations, improving OCR accuracy for license plate recognition, and optimizing the system's response time. Overall, the Automatic Surveillance System for detecting two-wheeler drivers without helmets and recognizing their license plate numbers and sending warning and fine SMS using Temporal Convolutional Network and Tesseract OCR is a promising solution for efficient and effective traffic rule enforcement. The system is designed and developed using Python Flask, Tensor Flow, and MySQL, making it highly efficient and scalable. It can be implemented in various traffic scenarios, including highways, roads, and city centres, to ensure traffic safety and reduce accidents. Overall, the Traffic Violation Finder is an effective solution that can contribute to making roads safer and more secure for everyone.

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