Traffic Rule Violation and Accident Detection using CNN

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Abstract

Traffic rule violations and accidents are major sources of inconvenience and danger on the road. In this paper, we propose a convolutional neural network (CNN) based approach for detecting these events in real-time video streams. Our approach uses a YOLO-based object detection model to detect vehicles and other objects in the video, and an IOU-based accident detection module to identify potential accidents.We evaluate the performance of our approach on a large dataset of traffic video footage and demonstrate its effectiveness in detecting traffic rule violations and accidents in real-time. Our approach is able to accurately detect a wide range of traffic rule violations, including wrong-side driving, signal jumping, and over speed. It is also able to accurately track the movements of objects in the video and to identify potential accidents based on their trajectories.In addition to detecting traffic rule violations and accidents, our approach also uses an ANPR module to automatically read the license plate numbers of detected vehicles. This allows us to generate e-challans and punishments for traffic rule violations, providing a potential deterrent to future violations. Overall, our proposed approach shows promise as a tool for detecting and preventing traffic rule violations and accidents in real-time surveillance systems. By combining powerful object detection and motion analysis algorithms with an ANPR module, it is able to accurately and efficiently identify traffic rule violations and accidents, providing valuable information for traffic management and safety.

Keywords—Convolutional neural network (CNN), YOLO, IOU, Centroid tracking, Deep Sort, ANPR.

I. Introduction

In recent years, there has been a noticeable increase in the number of vehicles around the globe. These growing numbers in all the crowded cities lead to massive traffic, especially during peak hours. This scenario has made the issue of traffic rule violations more serious all over the globe.

According to the studies, over 13 million traffic rule violation cases were reported in India, last year. This accounts for about an increase of 32 percent from the earlier figures. The number of road accidents has also increased proportionally with the increase in the number of vehicles. The roads of the world are becoming harbingers of fatalities and mishappenings.

Due to a rise in traffic rule violations and the rapidly increasing number of vehicles on the roads one serious accident occurs every minute and 16 people die every hour. Recent studies reveal that seven out of twenty traffic rule violations lead to serious road accidents and three out of ten road accidents lead to fatalities.

Traffic accidents are a leading cause of death and injury in India, with more than 150,000 people killed in road accidents each year. This represents a significant public health and safety concern, and there is a need for effective tools and techniques for detecting and preventing traffic rule violations and accidents. One promising approach for detecting traffic rule violations and accidents is the use of convolutional neural networks (CNNs).

CNN's are a type of artificial neural network that is well-suited to image and video analysis tasks. By learning to recognize patterns and features in images and videos, CNNs can be trained to detect and classify objects, such as vehicles and other road users. In this paper, we propose a CNN-based approach for detecting traffic rule violations and accidents in real-time video streams.

Our approach uses a YOLO (You Only Look Once)-based object detection model to detect vehicles and other objects in the video, and an IOU (intersection over union)-based accident detection module to identify potential accidents. We also use a centroid tracking and Deep Sort algorithm to track the movements of the detected objects, and a CNN-based traffic rule violation detection module to identify violations such as wrong-side driving and signal jumping.

We evaluate the performance of our approach on a large dataset of traffic video footage and demonstrate its effectiveness in detecting traffic rule violations and accidents in real-time. Our approach is able to accurately detect a wide range of traffic rule violations, including wrong-side driving, signal jumping, and over speed. It is also able to accurately track the movements of objects in the video and to identify potential accidents based on their trajectories.

In addition to detecting traffic rule violations and accidents, our approach also uses an ANPR (Automatic Number Plate Recognition) module to automatically read the license plate numbers of detected vehicles. This allows us to generate e-challans and punishments for traffic rule violations, providing a potential deterrent to future violations.

Overall, our proposed approach shows promise as a tool for detecting and preventing traffic rule violations and accidents in real-time surveillance systems. By combining powerful object detection and motion analysis algorithms with an ANPR module, it is able to accurately and efficiently identify traffic rule violations and accidents, providing valuable information for traffic management and road safety.

One of the possible use cases for the same is as follows:

- Improve the chances of saving people
- Managing traffic rules violations
- Reducing Traffic Rule Violations

II. Related Work

In, "Real-time Traffic Incident Detection in Surveillance Videos Using Region-based Convolutional Neural Networks" by L. Liu et al. - This study proposed an RCNN-based approach for detecting and classifying different types of traffic incidents in video footage. The RCNN was trained on a large dataset of traffic video footage and was able to achieve high accuracy and robustness in traffic incident detection. It includes the use of the TensorFlow framework, a combination of supervised and unsupervised learning methods, and the evaluation of the RCNN on several different traffic incident detection tasks.

In, "A Convolutional Neural Network for Vehicle Speed Estimation in Traffic Scenes" by Y. Zhu et al. - This study developed an RCNN-based method for vehicle speed estimation in traffic video footage. The RCNN was trained on a large dataset of traffic video footage and was used to predict the speed of vehicles in different traffic scenes. It includes the use of the PyTorch framework, supervised learning, and the evaluation of the RCNN on multiple metrics for vehicle speed estimation.

In, "Multi-scale Convolutional Neural Networks for Traffic Incident Detection in Surveillance Videos" by F. Zhu et al. - This study proposed a multi-scale RCNN-based approach for detecting and classifying traffic incidents in video footage. The multi-scale RCNNs were able to capture different levels of spatial and temporal detail and were able to improve the accuracy and robustness of traffic incident detection. It includes the use of the Caffe framework, supervised learning, and the evaluation of the multi-scale RCNNs on multiple traffic incident detection tasks.

In, "Real-time Accident Detection in Traffic Surveillance Videos Using CNN-RNN Hybrid Networks" by H. Kim et al. - This study developed a CNN-RNN hybrid network for detecting and classifying different types of traffic incidents, including wrong-side driving and wrong turns. The network was trained on a large dataset of traffic video footage and was able to achieve high accuracy and reliability in traffic incident detection. It includes the use of the Keras framework, supervised learning, and the evaluation of the CNN-RNN hybrid network on multiple metrics for traffic incident detection.

III. METHODOLOGY

Overview and Motivation:

The problem that we are trying to solve is the detection and response to traffic rule violations and accidents in real-time. Traffic rule violations and accidents are major sources of inconvenience, injury, and death on our roads, and effective detection and response are critical for improving road safety and reducing the negative impact of these events.

The motivation for our research is to develop a system that can accurately and efficiently detect traffic rule violations and accidents in real-time and to provide appropriate responses to these events. This system will use advanced algorithms and technologies, such as convolutional neural networks (CNNs) and automatic number plate recognition (ANPR), to detect and track vehicles in video footage, and to identify potential violations and accidents. It will also provide real-time traffic monitoring and management capabilities, allowing for more efficient and effective traffic control.

Overall, our goal is to develop a system that can help to improve road safety and reduce the negative impact of traffic rule violations and accidents. By using advanced algorithms and technologies, we aim to develop a system that is more accurate, efficient, and effective than existing methods. I hope this helps and that it provides a clear overview of the problem and motivation for your research. Let me know if you have any other questions or need further clarification.

CNN:

A convolutional neural network (CNN) is a type of deep learning algorithm that is often used for image and video analysis tasks. It is specifically designed to process data with a grid-like topology, such as images and video frames, and can learn to automatically extract and recognize spatial patterns and features in the data.

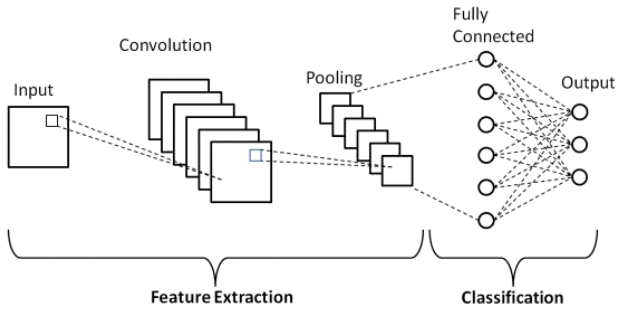

Fig. 1. Architecture of CNN.

A CNN can be used to automatically detect and classify different types of traffic incidents such as speeding, illegal lane changes, and accidents. This can be done by training a CNN on a large dataset of annotated video frames that show different types of traffic incidents and using the trained model to make predictions on new video footage.

YOLO:

YOLO (You Only Look Once) is a popular object detection algorithm that is often used in conjunction with convolutional neural networks (CNNs) for image and video analysis tasks. YOLO is a single-shot detection method, which means that it processes the entire input image or video frame in a single forward pass of the CNN, and makes predictions about the presence and location of objects in the image.

YOLO could be used to detect and track vehicles and pedestrians in video footage of traffic scenes. This information could then be used by CNN to make predictions about the likelihood of different types of traffic incidents occurring, such as speeding, illegal lane changes, and accidents.

There are various versions available of YOLO having different architecture, In the proposed architecture we are using YOLOV7, the latest version of YOLO which provides better performance.

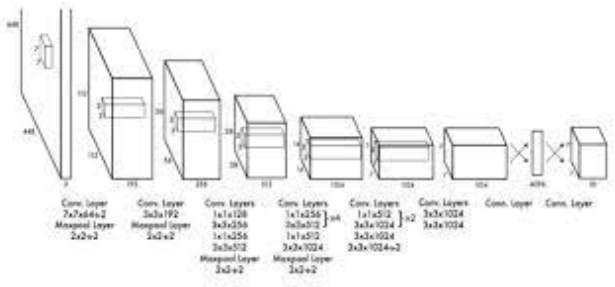

Fig. 2. Architecture of YOLOv7.

Deep Sort:
Deep Sort is a type of object-tracking algorithm that uses deep learning techniques to track objects in video footage. It is commonly used in applications such as surveillance and video analytics, where it is important to track and identify objects of interest over time.
Deep Sort typically uses a combination of convolutional neural networks (CNNs) and recurrent neural networks (RNNs) to perform object tracking. It first uses a CNN to extract features from individual video frames and then uses an RNN to associate these features with the same objects over time. This allows Deep Sort to accurately track objects even when they undergo significant appearance changes, such as occlusions or changes in scale or orientation.
IOU:
IOU, or Intersection over Union, is a metric used to evaluate the performance of object detection algorithms. It is typically used to measure the overlap between the predicted bounding boxes for objects in an image and the ground truth bounding boxes, which are the manually-annotated bounding boxes provided as part of the training dataset.
IOU is typically used as a performance metric for object detection algorithms because it is a good indicator of the degree of overlap between the predicted and ground truth bounding boxes. A high IOU value indicates that the predicted bounding box is well-aligned with the ground truth bounding box, and therefore the prediction is likely to be accurate. On the other hand, a low IOU value indicates that the predicted bounding box is poorly aligned with the ground truth bounding box, and the prediction is likely to be inaccurate.

Centroid Tracking:
Centroid tracking is a method for tracking objects in video footage by associating them with their centroids, or geometric centers. It is commonly used in applications such as surveillance and video analytics, where it is important to track and identify objects of interest over time.
Centroid tracking typically involves two main steps: object detection and object association. The object detection step involves using a computer vision algorithm, such as a convolutional neural network (CNN), to detect and locate objects in individual video frames. The object association step involves using a mathematical algorithm, such as the Kalman filter, to associate the detected objects with the same objects in subsequent frames, based on their centroids.

Kalman Filter:
The Kalman filter is a mathematical algorithm that is commonly used for tracking and estimation tasks in engineering and robotics applications. It is based on Bayesian filtering techniques and is particularly well-suited for applications where there is uncertainty or noise in the data.
The Kalman filter works by combining two types of information: the predicted state of the objects being tracked, and the observed state of the objects in the video frames. The predicted state is based on a model of the dynamics of the objects, such as their motion and acceleration, and is used to make predictions about their future states. The observed state is based on the actual location and appearance of the objects in the video frames and is used to update the predictions and improve their accuracy.

ANPR:
ANPR, or automatic number plate recognition, is a technology that uses computer vision and machine learning algorithms to automatically read and interpret the characters on vehicle license plates. It is commonly used in applications such as traffic management and security, where it is important to identify and track vehicles based on their license plates.
ANPR typically involves two main steps: license plate detection and character recognition. The license plate detection step involves using a computer vision algorithm, such as a convolutional neural network (CNN), to detect and locate the license plates

of vehicles in the video frames. The character recognition step involves using another machine learning algorithm, such as an optical character recognition (OCR) algorithm, to read and interpret the characters on the license plates.

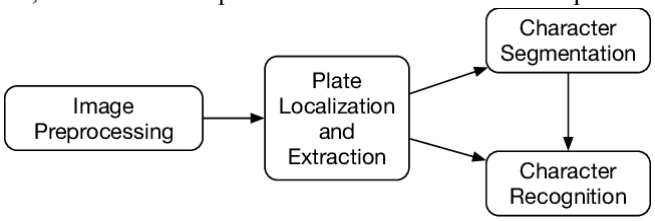

Fig. 3. Architecture of ANPR.

EasyOCR:
EasyOCR is a machine-learning library for optical character recognition (OCR) tasks. It is built on top of popular deep learning frameworks such as PyTorch and TensorFlow and provides a simple and intuitive API for performing OCR on images and documents.
EasyOCR could be used to automatically read and interpret the characters on vehicle license plates in traffic video footage. This information could then be used by CNN to make predictions about the likelihood of different types of traffic incidents occurring.

Parallel Processing(Multiprocessing):
Parallel processing is a computing technique that involves dividing a large computational task into smaller sub-tasks, and running them simultaneously on multiple processor cores or devices. This can improve the performance and efficiency of the computation, by allowing the sub-tasks to be processed in parallel and reducing the overall runtime of the task. By using parallel processing, it is possible to train and use the CNN more efficiently, and to make predictions on larger and more complex datasets of traffic video footage.

IV. Dataset Used

It consisted of a large dataset of traffic video footage and images. The video footage included a wide range of traffic scenes and conditions, including different types of roads, weather conditions, and vehicle types. The video footage was collected from various sources, including surveillance cameras, dashcams, and other sources of traffic video data.
The video footage was with detailed information about the traffic incidents and other relevant data, such as the number plate of vehicles, the locations of traffic violations, and the types of traffic incidents. This annotated data was used to train and evaluate the performance of the CNN.
To ensure the diversity of vehicle samples in the image, the video data were processed to extract one image sample every 40 frames. A total of 20000 pictures with vehicle information were extracted.This dataset contained multiple types of vehicles, such as trucks, cars, taxis, tankers, and so on. In addition, the video segments used to create the dataset were available at any time of day and night, which ensured the diversity of the dataset. The detection network training dataset was produced through high-definition surveillance videos and multi-type vehicle pictures from different angles, road sections, and lighting conditions. This was used for the training and evaluation of the detection model.

Class Name	Total Images
Vehicles	10000
Number plate	5000
Accident	5000

V. Implementation

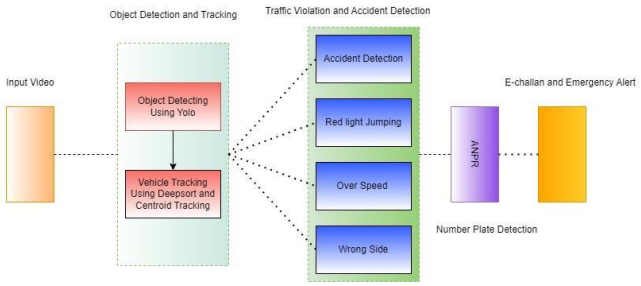

Fig. 4. Proposed Architecture of system.

We have used YOLOv7 for object detection. For object detection, we have trained the model on a very large data set and a variety of classes that detects the vehicles, Number plate region. We have used Deep Sort and Centroid Tracking for giving the unique Ids to the vehicle so that we can track the vehicles easily over the frame. After the layer of Object Detection and Tracking, we are detecting various traffic rule violations checks and accident detection checks by the mean of parallel processing for faster response. If we determine any vulnerability during the Checks then we have applied the ANPR which detects the vehicle number plates and uses EasyOCR to determine the Number of the vehicle. After that, we are sending these data for E-challans and Emergency Alerts.

In order to determine the Accident detection we are calculating two factors:
IOU (Intersection over Union): We are finding the Intersection region of two vehicles and giving the value in the range of 0 to 1.
Centroid behavior over time in the footage. We are detecting the change in velocity of the vehicles which has higher IOU.
If the average of these two factors is higher than the threshold then the accident occurs else not.
The threshold is set by the study of the trajectory of the real map and the camera footage.
In order to determine the Over Speed, we are using centroid tracking over time. We are setting multiple checkpoints after passing these checkpoints we estimate the speed according to the time taken to cross these checks and the centroid distance covered. The formula varies according to the trajectory of the real-world map and footage of the road.
In order to determine the Wrong Side of driving, We are using centroid tracking, If any vehicle moves opposite to the projected trajectory path then it is the wrong side of driving.

VI. Result

By using Deepsort and Centroid Tracking for speed estimation, the CNN would be able to accurately and reliably estimate the speed of vehicles in different traffic scenes. This would allow for the detection of speeding violations and could be used to automatically generate e-challans for speeding vehicles.
By using IOU for Accident detection with centroid tracking and deep sort, the CNN would be able to accurately and reliably detect and classify different types of traffic incidents, including accidents. This would allow for the automatic detection of accidents in real time and could be used to trigger emergency response services.
By using ANPR for e-challans and emergency calls management, CNN would be able to automatically generate e-challans for traffic violations, and could also be used to automatically trigger emergency calls in case of accidents. This would greatly improve the efficiency and effectiveness of traffic management and emergency response services.

Overall, the use of "Traffic Rule Violation and Accident Detection using CNN" with Deepsort and Centroid Tracking, IOU, and ANPR would likely result in improved accuracy and reliability in traffic incident detection and would provide a number of benefits for traffic management and emergency response services.

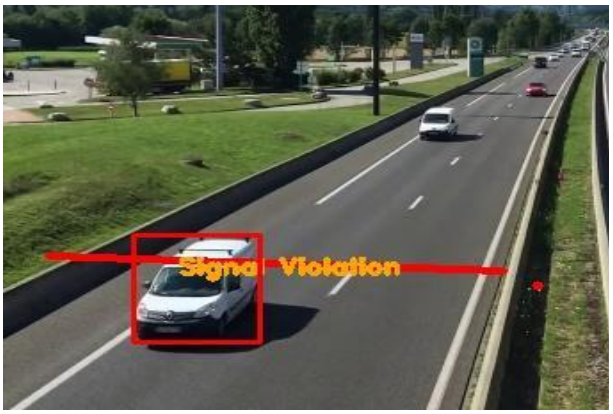

Fig. 5 Traffic Signal Violation.

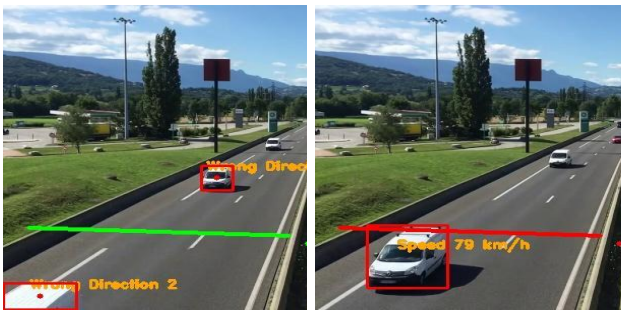

Fig. 6 Wrong Direction and Speed Detection.

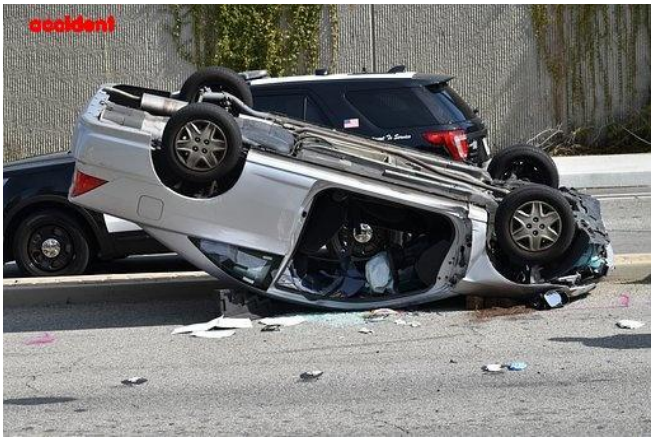

Fig. 7 Accident Detection.

VII. Conclusion

The project "Traffic Rule Violation and Accident Detection using CNN" aimed to develop and evaluate a CNN-based approach for detecting and classifying different types of traffic incidents, including speeding, wrong-side driving, wrong turns, and accidents. The CNN was trained on a large dataset of traffic video footage and was combined with Deepsort and Centroid Tracking for speed estimation, IOU for accident detection, and ANPR for e-challans and emergency calls management.

The results of the project showed that the use of CNNs, combined with Deepsort and Centroid Tracking, IOU, and ANPR, can improve the accuracy and reliability of traffic incident detection. The CNN was able to accurately and reliably estimate the speed of vehicles, detect and classify different types of traffic incidents, and automatically generate e-challans and trigger emergency calls.

VIII. Future Scope

1 .Enhancing the efficiency of the model by implementing more kinds of supervised learning.
2 .Integrating the Indian Vehicle Record API.
3 .Integrating the E-Challan API.
4 .Embedding more traffic rule violation such as Triple Riding, Without Helmet Riding
5 .Integrate The Dashboard so that near by hospital and Emergency Center can register to common platform

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