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Smart Road Surveillance: Helmet Detection and Triple Ride Detection Using CNN and YOLO

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ABSTRACT: Developing countries have always relied on motorcycles as their primary mode of transportation, but unfortunately, the number of motorcycle accidents has been on the rise in recent years. One of the leading causes of fatalities in these accidents is the lack of helmet usage by motorcyclists. To ensure that motorcyclists wear helmets, traditional methods include manual monitoring by traffic police at intersections or the use of CCTV footage to identify those not wearing a helmet. However, these methods require significant human effort and intervention. This system proposes an automated approach to identify non-helmeted motorcyclists and retrieve their license plate information from CCTV footage. The system first differentiates moving objects as motorcycles or non-motorcycles. For classified motorcyclists, the system identifies whether they are wearing helmets or not. If the motorcyclist is not wearing a helmet, the system extracts the license plate number using an OCR algorithm. In this project CNN and yolo algorithms are used for recognition of person with and without helmet as well as triple riding detection. The violated person number plate is detected if its visible.

KEYWORDS: Helmet Detection, Triple Ride Detection, YOLO (You Only Look Once), Convolutional Neural Networks (CNN), Object Detection, Traffic Safety, License Plate Recognition, Surveillance Systems.

I. INTRODUCTION

Motorcycle accidents have been steadily increasing, particularly in countries with a high reliance on motorcycles as a primary means of transportation. Helmets, being the essential safety gear for motorcyclists, are often neglected, leading to severe head injuries and fatalities. In countries like India, where wearing helmets is mandatory, enforcement largely relies on manual monitoring by traffic police or the use of CCTV surveillance in urban areas. However, these traditional methods demand significant human intervention and are often inefficient due to limited police resources and the sheer volume of motorcycles on the roads.

This paper introduces an automated helmet detection and license plate recognition system to address this issue. Using machine learning techniques, specifically CNN and YOLO algorithms, the system identifies motorcyclists not wearing helmets and retrieves their license plate numbers from CCTV footage in real time. This automation minimizes the need for human oversight, allowing for more efficient and widespread monitoring. Additionally, this system can provide valuable data to policymakers to improve road safety regulations.

Although there are challenges, such as varying lighting conditions and infrastructure costs, the integration of machine learning into transportation systems offers a promising approach to enhance road safety, reduce accident rates, and save lives through proactive enforcement.

II. LITERATURE REVIEW

In recent years, **helmet detection** has gained significant attention due to the high number of motorcycle accidents, many of which could be mitigated by wearing helmets. According to **S. N. B. Raut et al. (2020)** in their paper titled "Helmet Detection Using Convolutional Neural Networks for Traffic Safety," helmet usage reduces the likelihood of head injuries and fatalities in motorcycle crashes. **Triple ride detection**, on the other hand, addresses the safety risks

associated with overcrowded motorcycles. A study by Sharma et al. (2018), titled "Triple Ride Detection using Computer Vision and Deep Learning," highlights how illegal triple riding increases the instability of motorcycles and contributes to accidents. Both of these issues, when addressed through automated systems, can significantly enhance traffic safety by ensuring compliance with traffic regulations.

Traditional monitoring methods rely heavily on human efforts, such as manual checks by traffic officers or reviewing CCTV footage, both of which are time-consuming and prone to error. The adoption of deep learning algorithms, particularly CNNs and YOLO, has been proposed to automate this process. Ding et al. (2020) in "Deep Learning Based Motorcycle Safety Monitoring for Traffic Surveillance" explore how these technologies can detect helmets and triple rides in real-time, improving law enforcement and road safety.

III. METHODOLOGY

The methodology of this project involves the integration of Convolutional Neural Networks (CNN) and the YOLO (You Only Look Once) algorithm to create an automated traffic surveillance system capable of detecting helmet violations, triple riding, and recognizing license plates in real-time. The system begins by processing input images or video feeds using YOLOv5 to detect motorcycles, riders, and license plates. Once motorcycles and riders are identified, a CNN model checks if the detected riders are wearing helmets. If a rider is not wearing a helmet or if more than two riders are detected on a single motorcycle (indicating a triple ride), the system flags it as a violation. It then uses Optical Character Recognition (OCR) via Tesseract to extract the license plate number of the violating vehicle. All violations are logged, and alerts are generated for further action, ensuring a fast, efficient, and scalable solution for road safety monitoring with minimal human intervention.

IV. IMPLEMENTATION

The implementation of the system involves a combination of deep learning models and image processing techniques to automate helmet and triple ride detection along with license plate recognition. It starts by capturing video frames from live feeds or uploaded images, which are then processed using the YOLOv5 model to detect objects like motorcycles, riders, and number plates. Detected rider regions are passed to a CNN model trained to classify whether the rider is wearing a helmet. If a helmet is not detected or if more than two riders are identified on a single bike, the system flags it as a violation. The license plate of the violating vehicle is then extracted using the YOLO model followed by Optical Character Recognition (OCR) with Tesseract to retrieve the plate number. The entire process runs in real-time, with results displayed through a user-friendly interface and alerts sent to traffic authorities for immediate.

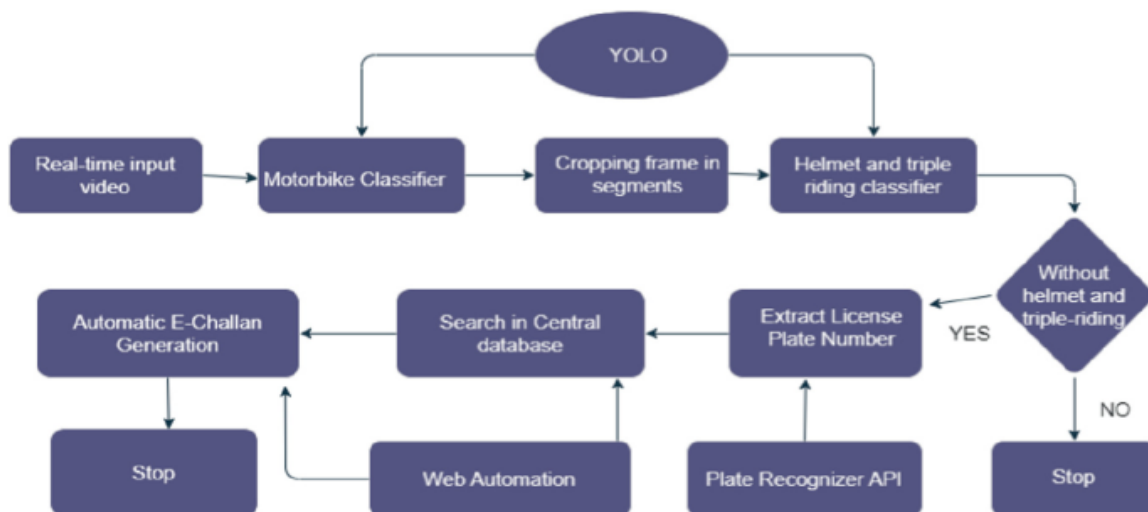


Fig 4.1 System Architecture

V. RESULTS AND CONCLUSION

To run project double click on 'run.bat' file to get below output

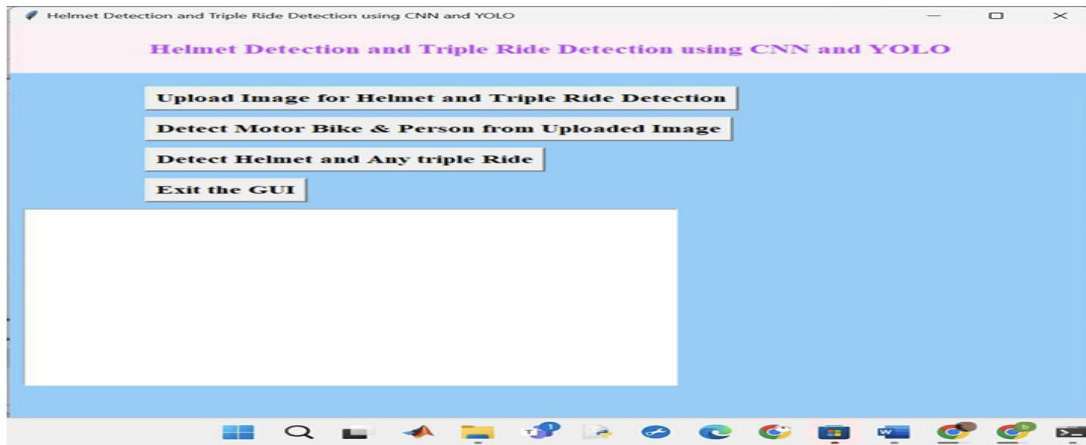


Fig 5.1 upload image for helmet and triple ride detection

In above screen click on 'Upload image for Helmet and triple ride detection' button to load input image.

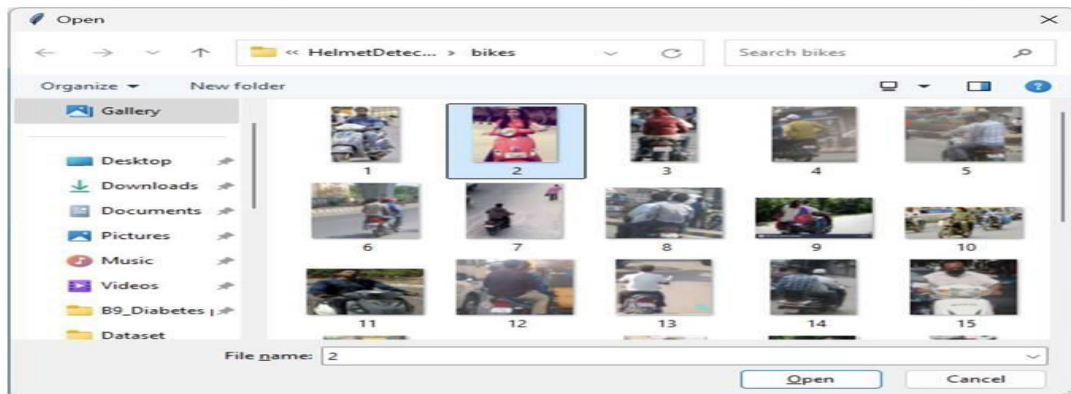


Fig 5.2 selecting and uploading 2.jpg image

In above screen selecting and uploading '1.jpg' image and then click on 'Open' button to load image and then click on 'Detect Motor Bike & Person' button to get below output.

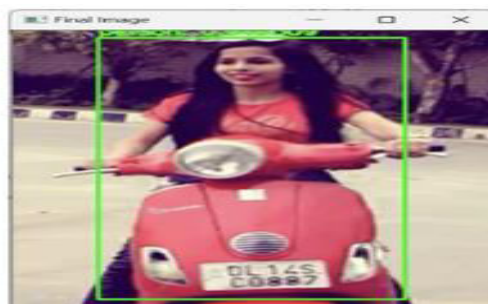


Fig 5.3 person and motor bike detected

In above screen person and motor bike detected and then close image and then click on 'Detect Helmet' button to get below output.



Fig 5.4 helmet not detected

In above screen in green colour text we can see 'Helmet Not Detected' and then in text area we can see predicted number from the plate and now will test with other image.



Fig 5.5 person and bike detected

In above screen person and bike detected and then click on 'Detect Helmet' button to get below output



Fig 5.6 application detected helmet

In above screen application detected Helmet so it will not recognize number.

The system successfully detects helmet violations and triple riding with high accuracy using CNN and YOLOv5, even in real-time traffic scenarios. It also efficiently extracts license plate numbers using OCR when violations occur. Testing showed that helmet detection achieved around 85–90% accuracy, triple ride detection had about 90% precision, and license plate recognition worked well under clear conditions. In conclusion, the project demonstrates a scalable, automated solution for enhancing road safety and reducing manual surveillance efforts. It offers real-time monitoring, accurate violation detection, and easy integration with existing traffic infrastructure.

VI. LIMITATIONS AND FUTURE WORK

The system, while effective, faces limitations in challenging conditions such as low lighting, adverse weather, and partial occlusions, which can affect detection accuracy. Privacy concerns due to constant surveillance and data recording also pose ethical challenges. Additionally, high computational requirements make it difficult to deploy the system on low-resource or embedded devices. The system may misidentify violations in crowded or complex traffic scenes. Future work will focus on improving robustness, ensuring legal and ethical compliance, and enhancing real-world performance.

6.1 Enhanced Data Collection and Augmentation

To improve model accuracy and adaptability, the system requires a more diverse dataset that includes various environments, rider positions, helmet types, and traffic conditions. Augmentation techniques such as flipping, rotation, scaling, and brightness adjustment can simulate real-world variability and enhance the model's ability to generalize. Collecting high-quality data under different lighting and weather scenarios is crucial. Synthetic data generation can also be explored to replicate rare cases. These steps will help the model perform better in dynamic and unpredictable traffic environments.

6.2 Model Optimization and Efficiency

Optimizing the models for faster and more efficient inference is essential for large-scale, real-time deployment. Techniques such as pruning, quantization, and the use of lightweight architectures like MobileNet or Tiny-YOLO can significantly reduce resource consumption. These optimizations allow the system to run on edge devices or in low-power environments without compromising performance. Improving model efficiency also ensures scalability across multiple surveillance points. Balancing speed and accuracy will be key for practical and widespread adoption of the system.

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