International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 03 | March - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Helmet Detection and Triple Ride Detection using CNN and YOLO

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***Abstract*—Motorcycles have been the primary means of transportation in developing countries. Unfortunately, the motorcycle accident cases have been very high recently. Most of the death toll in these motorcycle accidents is due to the fact that motorcyclists fail to wear helmets. How best the motorcyclists are ensured to put on their helmets goes a long way with which technology is utilized: from monitoring the police manual at the intersections or CCTV footage to capture those without a helmet. However these methods consume considerable human effort and interaction. This system contemplates an automated scheme for the detection of helmet less motorcyclists and retrieves license number from CCTV footage. The system first categorizes moving objects as motorcycles or otherwise. For classified motorcyclists, the system determines whether they wear helmets or not. In case, the motorcyclist does not wear a helmet, the system retrieves 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: Motorcycles, Helmet usage, CCTV footage, automated approach, Non-helmeted motorcyclists, license plate, moving objects, CNN (Convolutional Neural Networks), YOLO (You Only Look Once), recognition, OCR (Optical Character Recognition)

I. Introduction

Road safety is a pressing global issue, with approximately 1.35 million people dying and 50 million getting injured annually due to road accidents, as reported by the World Health Organization in their 2018 Global Status Report. Among these casualties, motorcyclists, cyclists, and pedestrians are disproportionately affected. India, in particular, faces a severe road safety crisis, ranking highest in road crash deaths. Contributing factors include rapid urbanization and widespread neglect of safety measures like helmets and seat belts. In response to this challenge, India committed to reducing road crash deaths by 50 percent by 2020 through the Brasilia Declaration on Road Safety. Despite these efforts, effective implementation remains a challenge. Helmets play a crucial role in mitigating fatal head injuries by absorbing collision impacts and distributing forces more evenly across the skull. However, ensuring consistent helmet use remains problematic, exacerbated by inadequate enforcement mechanisms and limitations in current surveillance systems.

Automating the detection of helmet use in motorcycle riders presents several challenges. One significant issue is occlusion, where objects obscure one another, making it difficult to detect partially visible helmets.[4] Additionally, motorcycles and riders appear differently from various angles, complicating the classification process. Changes in environmental conditions, such as varying lighting and weather, further impact the effectiveness of detection systems. Low-resolution video feeds from surveillance cameras also pose a problem, as they can make it harder to accurately segment and classify objects.[7] Recent advancements in machine learning and deep learning, such as the use of YOLOv3 and YOLOv5 models, aim to address these challenges by improving real-time detection capabilities and handling complex conditions. These systems are designed to integrate with existing CCTV infrastructure to enhance the efficiency of helmet use monitoring and license plate recognition, reducing the need for manual intervention and improving overall road safety.[12]

Real-time monitoring systems for detecting helmet use and license plate recognition are crucial for improving road safety. Traditional methods relying on human surveillance are often inefficient and prone to errors, particularly as the number of motorcyclists increases.[13] Automated systems leverage advanced technologies such as deep learning and object detection to monitor helmet use continuously and accurately. For instance, models like YOLOv3 and YOLOv5 can detect helmets and license plates in real-time, even under challenging conditions such as poor lighting or high traffic density. These systems not only enhance the effectiveness of law enforcement but also reduce the workload on traffic police by automating the detection process.[11] The integration of these technologies with existing CCTV networks allows for more efficient and scalable monitoring, leading to a reduction in road traffic violations and potentially saving lives by ensuring greater adherence to helmet laws.

In addressing the challenge of helmet detection and license plate recognition for improving road safety, Convolutional Neural Networks (CNNs) and YOLO (You Only Look Once) models have emerged as pivotal technologies. CNNs are highly effective for object detection tasks due to their ability to automatically extract features from images, making them ideal for identifying helmets and license plates.[7] Traditional object detection methods relied on feature extraction techniques like

Haar cascades and Histogram of Oriented Gradients (HOG), which, although useful, often struggled with real-time accuracy and efficiency.

YOLO, particularly its versions YOLOv3 and YOLOv5, represents a significant advancement in this domain. YOLO models are designed to perform object detection in a single pass through the network, which allows for real-time processing with high accuracy. YOLOv3 offers robust performance with near real-time processing capabilities, handling complex scenarios such as varying lighting and diverse angles of view.[6] YOLOv5 further improves on this with enhanced speed and reduced model complexity, making it suitable for deployment on embedded systems with lower computational resources.

The integration of CNNs with YOLO models enhances the capability to detect whether motorcyclists are wearing helmets and to recognize license plates with greater precision. These systems can process video feeds from CCTV cameras to automatically identify traffic violations, significantly reducing the need for manual monitoring and increasing overall enforcement efficiency.[8] By leveraging these advanced technologies, road safety measures can be more effectively implemented, leading to a potential decrease in accidents and fatalities.

II. LITERATURE SURVEY

A. Helmet Detection on Motorcyclists Using Image Descriptors and Classifiers

Motorcycle crashes have been growing significantly in recent years in most countries. This type of vehicle is gaining popularity in the market place due to various social as well as economic reasons. For a motorcycle user, a helmet is considered as the protective gear, but most of the drivers do not use it. According to me, the primary purpose of a helmet is to protect the head of the driver at the time of accident. In case of an accident, if it does not use then can lead to death. This paper proposes a system to recognize the motorcyclist without helmet. For that purpose, we have applied the Using circular Hough transform along with the Histogram of Oriented Gradients descriptor for extracting image features, followed by a Multi Layer Perceptron classifier in classification procedure and comparison of the results with other algorithms. The available database is given to traffic images captured by cameras from public roads and encompasses 255 images. Indeed the algorithm step regards the helmet detection reached an accuracy level of 91.37 percentage.[1]

B. Safety helmet wearing detection based on image processing and machine learning. In Advanced Computational Intelligence (ICACI):

This paper presents a new development towards helmet detection in the power substation application by the use of image processing techniques and machine learning algorithms. It applies the ViBe background modeling to extract motion objects from the surveillance video and Histogram of Oriented Gradient to describe pedestrian detection. Then, the detection of pedestrians is followed by the involvement of an SVM classifier while the detection of a helmet is based on the color recognition technique. This method proves effective in enhancing safety monitoring in substations where less extensive labor-intensive supervision is required. As compared to earlier work relating to motorcyclist monitoring, this approach advances safety by targeting industrial environments like substations about helmet detection.[2]

C. Automatic detection of bike-riders without helmet using surveillance videos in real-time:

In fact, the paper offers a real-time helmetless bike rider detection approach from the surveillance video. The approach requires background subtraction or object segmentation to detect riders and later uses visual features, by means of a binary classifier, to detect helmets on the heads of riders. HOG, SIFT, and LBP feature representations are compared three times in the approach. As a result, the real-world image yields 93.80 percent detection accuracy and gives 11.58 ms per frame processing time. It provides minimization of reliance on human monitoring and is relatively better in reliability, as it achieves the same without extra costs through the use of existing surveillance infrastructure. It increases the impetus to curb the dangers of riding without helmets and helps in establishing conformity with certain traffic regulations.[3]

D. Detection of motorcyclists without helmet in videos using convolutional neural network:

This paper describes an automatic detector for identifying helmet-less motorcyclists using surveillance videos. This concept utilizes adaptive background subtraction to detect moving objects, followed by the application of a CNN in the detection of motorcyclists. Then, the upper section is passed to another CNN for detecting helmetless riders. The system was tested using two datasets, and it achieved 92.87 percent detection accuracy with a false alarm rate of 0.5 percent. With the increasing motorcycle accidents related to helmet non-compliance, the proposed system provides a cost-effective, automated mechanism to strengthen the enforcement mechanisms using existing video surveillance infrastructure.[4]

E. ImageNet: A Large-Scale Hierarchical Image Database:

ImageNet is a large-scale ontology of images designed to address the challenge of organizing and interacting with vast amounts of image data. Built on the WordNet structure, ImageNet aims to populate around 80,000 synsets with 500–1000 high-quality, full-resolution images each, resulting in tens of millions of annotated images organized by semantic hierarchy. The current version includes 5247 synsets and 3.2 million images, making it significantly larger, more diverse, and more accurate than existing datasets. ImageNet's construction involved crowdsourcing via Amazon Mechanical Turk. The database's scale and structure provide valuable opportunities for advancements in object recognition, classification, and clustering.[7]

F. Densely Connected Convolutional Networks:

Dense Convolutional Networks (DenseNets) improve the accuracy and efficiency of training deep convolutional networks by introducing shorter connections between layers. Unlike traditional networks, where each layer connects only to the next, DenseNets connect each layer to every other layer, resulting in L(L+1)/2 direct connections in a network with L layers. This structure strengthens feature propagation, promotes feature reuse, and mitigates the vanishing gradient problem, all while reducing the number of parameters. DenseNets deliver significant improvements on object recognition benchmarks like CIFAR-10, CIFAR-100, SVHN, and ImageNet, achieving better performance with less memory and computation.

G. Scalable and Accurate Deep Learning for Electronic Health Records:

The proposed study presents an approach in predictive modeling based on deep learning from raw Electronic Health Records (EHR) in Fast Healthcare Interoperability Resources (FHIR) format. Instead of curating data for the use of traditional models, it uses raw EHRs that include clinical notes to predict medical outcomes. The model was tested on deidentified data from 216,221 patients across two U.S. medical centers and showed excellent accuracy in the prediction of in-hospital mortality (AUROC 0.93-0.94), 30-day unplanned readmission, and discharge diagnoses. Traditional models were much inferior to this model, and it possesses transparency with an attribution system utilizing a neural network for clinicians to trace the predictions back to specific patient data points.[10]

H. Helmet Detection using Machine Learning and Automatic License Plate Recognition:

In response to the rising number of motorcycle accidents, a machine learning-based system has been developed for automatic detection of helmet use among motorcyclists. The model detects riders using computer vision techniques and identifies helmetless riders. Upon detection, the system extracts the license plate and uses Optical Character Recognition (OCR) to recognize and record the license number. This system can be implemented in real-time using a webcam or CCTV feed. Leveraging machine learning algorithms, the model is trained with a specific dataset to accurately detect helmet use and ensure road safety by monitoring and reporting violations.

III. RELATED WORK

In recent years, the integration of automatic helmet detection and number plate recognition has become crucial in monitoring road safety. Various studies have explored methods for helmet detection on motorcyclists, using techniques such as color histograms, edge orientation histograms, and Haar-like features. For instance, Silva et al. (2014) applied image descriptors and classifiers to detect helmets, while Li et al. (2017) developed a system that combined image segmentation, feature extraction, and SVM for classification, achieving significant accuracy. Similarly, Dahiya et al. (2016) utilized background subtraction and face detection to detect helmetless riders in real-time surveillance. The advancements in deep learning, especially CNN-based architectures like YOLO (You Only Look Once), have propelled object detection tasks, making it possible to detect helmets and recognize number plates more efficiently. Vishnu et al. (2017) demonstrated the power of CNNs in handling large-scale datasets for helmet detection, contributing significantly to road safety and automated monitoring systems.

The YOLO series, including YOLOv2, YOLOv3, and YOLOv5, have gained prominence in real-time object detection. The models offer a balance between speed and accuracy, making them suitable for helmet detection and number plate recognition applications. Unlike traditional two-stage detection algorithms like R-CNN or Fast R-CNN, which focus on region proposals and classification, YOLO directly predicts object categories and locations, allowing for real-time analysis. Allamki et al. employed YOLOv3-tiny to detect multiple categories, including the rider, helmet, and license plate. This approach streamlines the process of identifying violators, although it may struggle with rear passengers or environmental interferences. M. Srilakshmi and Jimit Mistry also used YOLO-based models, detecting motorcycles, helmets, and license plates in a stepwise manner. Despite the improvements in real-time object detection, some challenges remain, such as the need for high-precision detection in complex environments.

The implementation of these models in real-world applications involves multiple modules, including loading the YOLO model, detecting bikes and helmets, and recognizing license plates. However, the systems face certain drawbacks, such as privacy concerns, as individuals may be uncomfortable with their images being captured without consent. Moreover, helmet detection and number plate recognition algorithms may not always deliver accurate results, especially under challenging conditions like poor lighting, adverse weather, or occlusions from other vehicles or pedestrians. While deep learning and computer vision have made significant strides in automating road safety monitoring, further advancements are needed to enhance precision and reliability across varying conditions. Despite these challenges, the application of AI-based surveillance systems continues to offer promising solutions for reducing traffic violations and improving overall road safety.

IV. PROPOSED METHOD

The use of frontline computer vision technologies to propose an automatic helmet detection and number plate recognition system could further improve the safety and security of motorcyclists and vehicle management. The proposed system shall be working with two core elements: helmet detection and number plate recognition, based on the YOLOv5 algorithm. YOLOv5 is one of the most popular object detection algorithms which achieves better accuracy and efficiency for real-time video analysis. To achieve the objective of detection of helmets in the system, a YOLOv5 model has been fine-tuned on an extensive dataset of annotated images and videos. The diversity training on this data makes it possible for the model to correctly identify and localize helmets on motorcyclists under different real-world scenarios. In this helmet detection approach, YOLOv5 does video frames inference to predict bounding boxes on the detected helmets. The use of non-maximum suppression results in the accurate detection; these suppress the detections and merge the duplicate results into the most precise bounding boxes. The number plate recognition

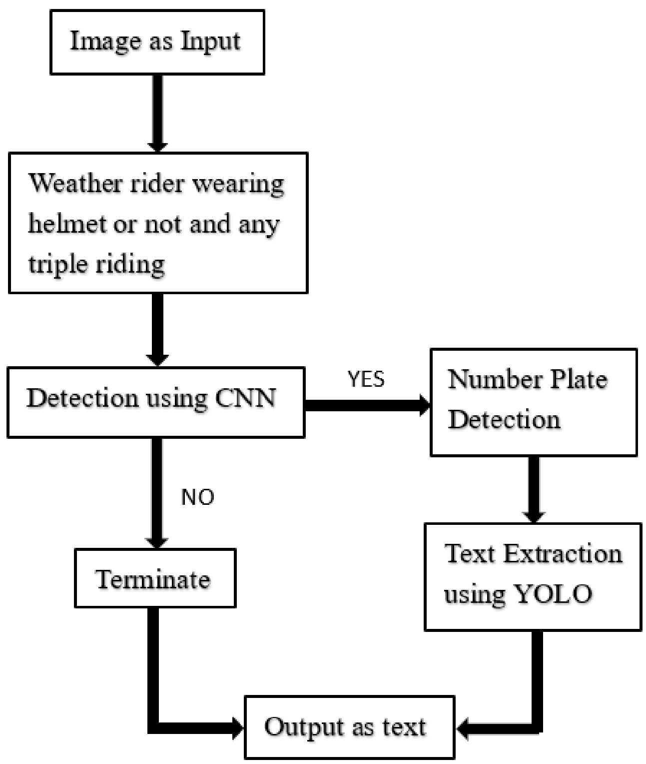

Fig. 1. System Architecture

component exploits the results of the helmet detection stage. It extracts ROIs representing the detected number plates. Various pre-processing techniques have been utilized in an effort to enhance image quality and legibility of the number plate, including noise reduction, contrast adjustments, and thresholding. After preprocessing, the algorithms used by OCR can pick up alphanumeric characters from the pre-processed number plate regions. This sophisticated step helps to enhance the readability of number plates and helps determine vehicle information with accuracy. This advanced system forms an effective tool for monitoring and managing road safety and in controlling traffic flow and law enforcement.

Advantages of Proposed Method: The proposed system offers several key advantages, particularly in the realm of traffic management and road safety. By utilizing this automated helmet detection and number plate recognition system, it becomes possible to identify motorcyclists who are not wearing helmets from CCTV footage with high precision. This capability significantly contributes to promoting road safety by ensuring compliance with helmet-wearing regulations, which can dramatically reduce the risk of head injuries in the event

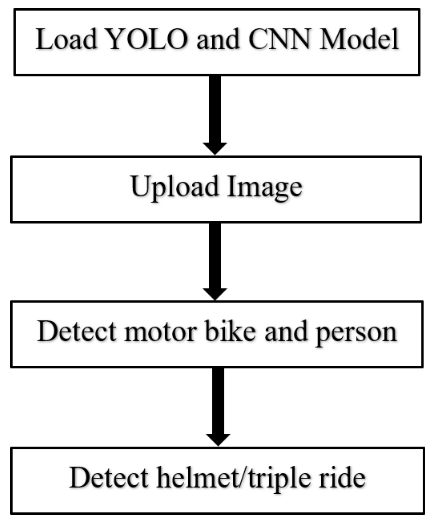

Fig. 2. Implementation Flochart

of accidents. Additionally, the system supports traffic management and law enforcement by enabling efficient monitoring of traffic flow and identifying traffic violations. The integration of helmet detection ensures that motorcyclists adhere to safety norms, while the number plate recognition component aids in tracking vehicles, managing congestion, and enforcing traffic rules more effectively. Overall, this system enhances both security and efficiency on the roads, benefiting public safety and contributing to improved traffic management strategies.

V. Conclusion

In conclusion, this project presents a robust framework for enhancing road safety through the automatic detection of helmetless motorcyclists and the retrieval of their vehicle license plates from CCTV video feeds. Utilizing Convolutional Neural Networks (CNNs) and transfer learning, the system achieves high accuracy in identifying riders who are not wearing helmets, a crucial aspect in enforcing helmet laws. Beyond mere detection, the framework's capability to recognize and store license plate numbers enables the systematic identification and penalization of helmet law violators. This dual functionality not only aids in immediate enforcement but also provides valuable data for ongoing safety monitoring. The implementation of this framework offers significant benefits by integrating seamlessly with existing CCTV networks, thus leveraging pre-installed infrastructure for enhanced road safety management. The adaptability provided by transfer learning ensures that the system can be effectively deployed in various environments, making it a scalable solution for diverse locations. This adaptability is vital for addressing different conditions and requirements in urban and rural settings alike.

Overall, the project underscores the transformative potential of AI and machine learning in advancing road safety. By delivering a comprehensive solution that combines helmet detection with vehicle identification, the framework has the ca-

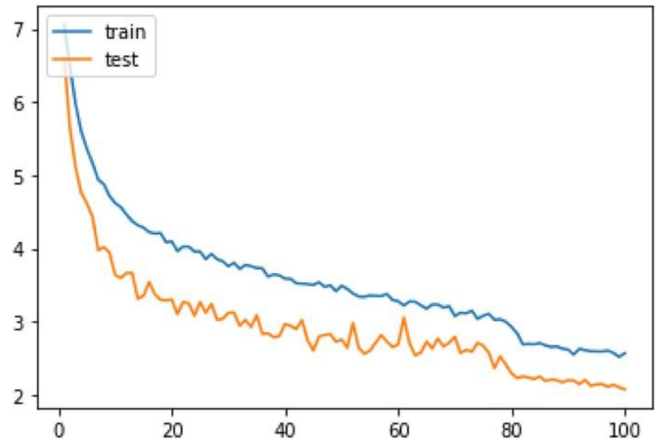

Fig. 3. Training accuracy and loss graph

pability to significantly reduce traffic accidents and contribute to saving lives. The successful application of this technology demonstrates its promise as a practical and impactful tool in promoting safer roads and enforcing traffic regulations more effectively.

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