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ADVANCEMENTS IN MOTORCYCLE SAFETY: AUTOMATIC HELMET DETECTION SYSTEMS THROUGH MACHINE LEARNING

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Abstract : Motorcycle accidents are a huge concern today. The number of accidents occurring every day has increased rapidly which in turn results in loss of lives. One of the main factors in these fatal accidents is the lack of use of helmets. Even though the use of a helmet is mandatory people fail to follow it which causes these unfortunate events. The government has taken various initiatives regarding the increase in the use of helmets by creating awareness and also increasing the fines but people seem to be least bothered. To tackle these situations, we propose an automated solution for helmet detection on motorcyclists using a combination of techniques like YOLO and CNN. The combination of You Only Look Once(YOLO) and Convolutional Neural Network(CNN) helps to efficiently identify the helmets from the real-time datasets. The proposed system will help traffic police by reducing their work and automating the imposition of fines. As the techniques are used in combination, the accuracy and the degree of reliability of our system are higher compared to single techniques-based implementations**.**

Keywords— Open CV-Open-Source Computer Vision Library ,CNN-Convolutional Neural Network ,OCR-Optical Character Recognition ,YOLO-You Only Look Once ,IOU-Intersection over Union ,DHCP-Dynamic Host Configuration Protocol ,DDNS-Dynamic Domain Name System ,PoE-Power over Ethernet ,API-Application Programming Interface.

I. INTRODUCTION

While driving down a bustling avenue, I spot a motorcyclist without a helmet, which unfortunately is not an unusual sight in many parts of the world. This situation poses a severe safety concern. Despite traffic rules mandating helmet use, a significant number of riders choose to ride without this essential protection. This not only endangers the helmetless riders themselves but also jeopardizes the safety of everyone sharing the road with them.

For instance, in India, six motorcyclists lose their lives in road accidents every hour. This alarming statistic underscores the seriousness of the issue. What's even worse is that this disregard for safety measures often persists during a global pandemic, where mask-wearing takes center stage, sometimes at the expense of wearing helmets. This results in an increased frequency of traffic violations and places more lives at risk.

To address this pressing problem, we have initiated a research project aimed at tackling the issue of motorcyclists riding without helmets. Our approach combines the latest machine learning techniques and advanced object detection algorithms to automatically identify individuals violating helmet regulations. However, our project does not stop there. We also aim to capture the license plates of these offenders. Our ultimate goal is to provide a comprehensive solution that enables authorities to enforce traffic laws more effectively and, in doing so, protect the well-being of all road users.

Our research introduces a fresh and innovative approach to road safety issues. We leverage the YOLOv5 (You Only Look Once) algorithm, well-known for its real-time object detection capabilities. We complement this with transfer learning techniques, enabling accurate detection and categorization of motorcyclists. These techniques offer a robust solution for identifying individuals not wearing helmets, distinguishing them from pedestrians, and automatically recording their registration code details.

[1]According to an official statement, of the nearly 15,000 road accident fatalities reported in Maharashtra in 2022, 7,700 involved motorcycle riders. The majority of these deaths were a result of head injuries caused by the failure to wear a helmet. This information

was released by the state transport commissioner in a recent report. In response to this situation, the state transport department has instructed its personnel to launch a nationwide campaign to educate two-wheeler users about the importance of road safety and the legal regulations related to it.
According to reliable statistics, over 7,000 motorcycle riders died in Maharashtra in 2022, primarily due to their failure to wear helmets.
In line with official statistics, Maharashtra recorded almost 7,000 motorcycle rider deaths in 2022, with the majority of these fatalities resulting from the lack of helmet usage.
According to official data released earlier this year, 14,883 people nationwide lost their lives in traffic accidents in 2022, marking a 2.5% increase from the 12,788 fatalities reported in the year before the Covid-19 pandemic in 2019. The transport commissioner noted in the report that out of the 7,700 road accident fatalities in 2022, 51% were attributed to motorcycle riders, and the majority of these cases were a result of head injuries from riders not wearing helmets.
The report described the situation as extremely concerning and stated that it was observed that the goals set by the World Health Organization to reduce road injuries by 50% by 2030 are not being rigorously adhered to. "The transport commissioner has directed all local transport offices (RTOs) to reduce instances of underage driving and to impose fines under the Motor Vehicles Act on those under the age of 18 who are found operating two-wheelers," a dignified statement said.

II. LITERATURE REVIEW

M. Anne Sanchana and S. Eliyas(2023) [2] An automated motorcycle helmet detection system using YOLO and CNN techniques to improve road safety by identifying helmet usage. It highlights the importance of helmets in preventing accidents and the need for automated detection. The study achieved an accuracy rate of 94.29% and suggests future work involving hardware implementation and mobile phone usage detection. The document references several related studies on helmet detection using deep learning methods.

H. Lin, J. D. Deng, D. Albers and F. W. Siebert(2020) [5] a deep learning-based method for automatically detecting and tracking motorcycle helmet use. This approach encompasses the detection and tracking of active motorcycles, identification of rider numbers, positions, and helmet use. The method demonstrates high accuracy, especially in frame-based motorcycle detection and tracking, although it encounters challenges in uncommon traffic scenarios and environments with parked motorcycles. introduces the HELMET dataset for training and evaluating similar detection approaches, addressing existing dataset limitations and advancing the field of automated helmet detection.

Jia, W., Xu, S., Liang, Z., Zhao, Y., Min, H., Li, S., & Yu, Y. (2021).[8] presents a real-time automatic helmet detection system for motorcyclists in urban traffic using an improved YOLOv5 detector. The system comprises two stages: motorcycle detection and helmet detection. It achieves high accuracy with a mAP of 97.7% for motorcycle helmet detection, and it can identify overloaded motorcycles. The proposed method shows promise for enhancing traffic safety and can potentially be integrated into video surveillance systems for real-world applications.

N. Kharade, S. Mane, J. Raghav, N. Alle, A. Khatavkar and G. Navale (2021) [4] This addresses the critical issue of motorcycle rider safety by focusing on helmet detection. It introduces a deep learning approach using the YOLOv4 model to automatically differentiate between helmeted and non-helmeted motorcyclists in traffic videos. The proposed model outperforms existing CNN-based methods, contributing to improved safety regulation enforcement and accident prevention.

S. Maheswaran et al.(2022) [12] describes a real-time Automatic Number Plate and Helmet Recognition System based on YOLOv5, a state-of-the-art computer vision technique. It outlines the process of collecting, annotating, and training a dataset to detect riders with and without helmets and recognize number plates. The system achieves an 82% average confidence score for helmet detection and successfully identifies number plates. It proposes further enhancements for real-world implementation and references prior research in the field.

III. PROPOSED SYSTEM

Our Proposed System is independent to device. is an intelligent traffic violation detection system that leverages machine learning techniques, particularly the YOLO (You Only Look Once) technology. The core functionality of the system revolves around training on a comprehensive dataset containing images and videos depicting various traffic violations. The primary focus is on detecting and categorizing traffic violations, with a specific emphasis on motorcyclists without helmets.
The application will contain the following Algorithms:

•YOLO (You Only Look Once):
YOLO, or "You Only Look Once," is a widely-used collection of computer vision models designed for real-time object detection and classification. Initially created by Joseph Redmon, Ali Farhadi, and Santosh Divvala, YOLO's primary goal is to provide precise object detection while maintaining real-time processing speeds. These models fall into the category of one-stage object detection models, as they can analyses an entire image in a single pass through a convolutional neural network (CNN).

•Open CV (Open Computer Vision):
OpenCV is an indispensable component within the system designed for the detection of helmets and number plates. OpenCV, an acronym for Open-Source Computer Vision Library, is a widely utilized open-source software library for computer vision and machine learning. It is extensively employed for various image and video processing tasks.

•CNN (Convolutional Neural Network):
In the realm of automatic helmet detection structures, Convolutional Neural Networks (CNNs) are a vital architectural choice. These systems harness the electricity of deep learning, studying at once from snap shots, to put in force site visitors protection regulations. Understanding how CNNs paintings within the context of helmet detection involves three key ideas: local receptive fields, shared weight and bias, and robustness and convergence.

A. System Architecture

The major components of our application are shown in Fig.1.

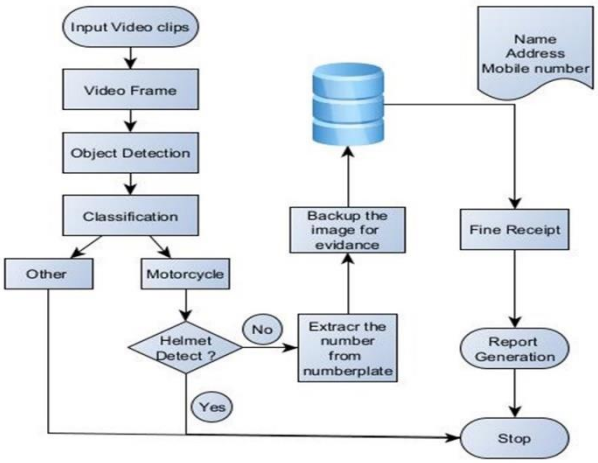

Fig. 1. System Architecture

B.UML Diagrams

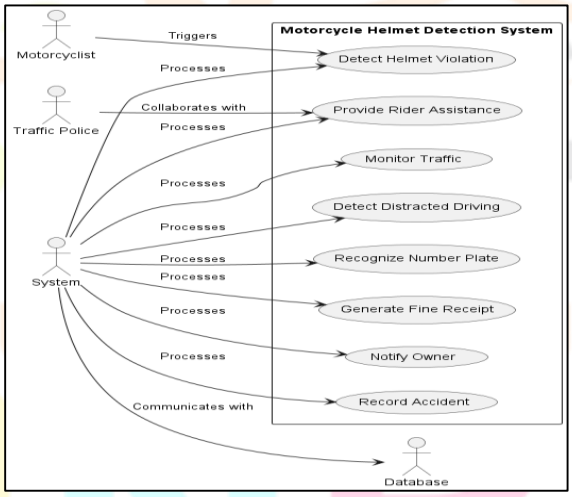

Fig. 2. Use Case Diagram

C.Additional Features

Real-time Surveillance System: The system, particularly using YOLO V8, enables real-time surveillance for detecting people, vehicles, and objects of interest in video footage. This can contribute to public safety, crime prevention, and monitoring traffic conditions.
Optical Character Recognition (OCR): OCR for extracting information from license plates. This feature involves multiple steps, including photograph capture, preprocessing, segmentation, standardization, feature exploitation, recognition, classification, and result evaluation.
OpenCV Integration: The system incorporates OpenCV for various tasks, including video frame analysis, object detection (helmets and number plates), algorithm integration with YOLO and CNN, and pre-processing tasks like noise reduction and contrast adjustment.
Convolutional Neural Network (CNN): The use of CNN is highlighted for automatic helmet detection. CNNs provide a vital architectural choice for deep learning, focusing on local receptive fields, weight sharing, bias, and robustness. Transfer learning and feature extraction are mentioned as potential approaches for CNN implementation.
Traffic Violation Detection: The system has the capability to detect helmet violations in real-time traffic scenarios. This contributes to enhanced traffic safety and regulatory enforcement.
Application in Various Domains: diverse applications, including traffic police assistance, distracted driving detection, accident documentation, emergency response, rider assistance, smart traffic management, and helmet detection in construction sites.

Limitations and Challenges: several limitations, such as the impact of image quality on system performance, the need for night vision cameras, sensitivity to harsh weather conditions, continuous cloud connectivity, and access to the RTO database for imposing fines.

D. Challenges and Future Directions

Image Quality Impact: The system's performance is susceptible to the quality of images and videos. Factors such as blurriness, poor lighting conditions, and shadows can lead to incorrect predictions, impacting the accuracy of helmet and license plate detection.
Night Vision Requirement: To maintain the quality of live feed during nighttime, night vision cameras are essential. This introduces a hardware requirement that might increase the overall system cost and complexity.
Weather Conditions: Harsh weather conditions, such as rain or fog, can introduce noise into the images, potentially affecting the accuracy of the detection system. Adverse weather scenarios need to be addressed for reliable operation.
Helmet Detection in Construction Sites: The system's capabilities can be extended to include the detection of helmets on workers in construction sites. This expansion would contribute to safety regulation compliance in industrial settings.
Motion-Based Tracking: Implementing a system that activates CCTV cameras only when a vehicle is within range could save power and reduce the load on the central server. This optimization aligns with efficient resource utilization.
Evolution of System Capabilities: The current focus on helmet detection could evolve to address more complex tasks in the future. This includes the detection of distracted driving behaviors, real-time rider assistance, accident documentation, and enhanced traffic information provision. wonders

IV. RESULTS

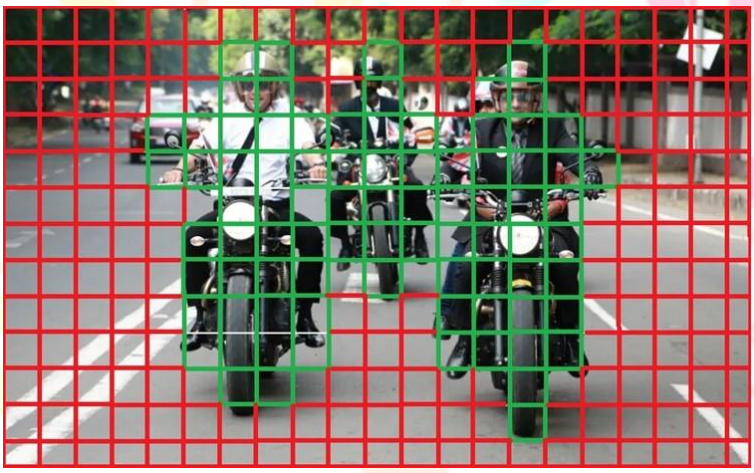

Fig. 3. *Residual Blocks*

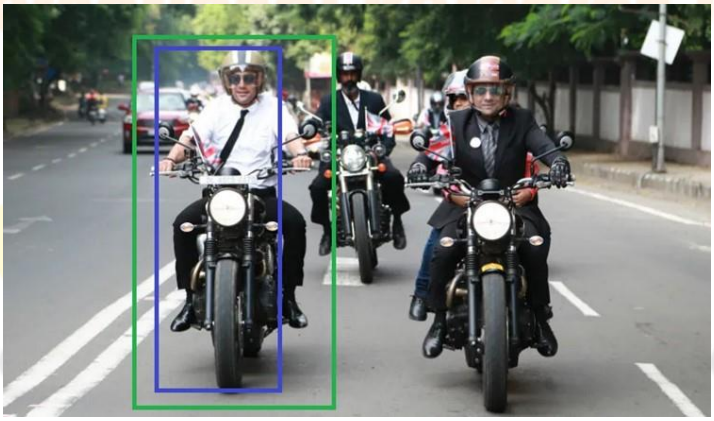

Fig. 4. Image Annotation

Fig. 5.: OCR

V. CONCLUSION

By addressing the gaps identified above a progressive clever traffic violation detection device harnessing the electricity of Machine Learning. The device's centre capability revolves round its capacity to be trained on a complete dataset comprising both photographs and movies presenting instances of numerous site visitors violations. To enhance its accuracy and precision, the proposed machine ingeniously uses YOLO (You Only Look Once) technology. By doing so, it ensures a sturdy foundation for identifying and categorizing visitors violations with excellent efficiency. This clever machine is poised to make a significant impact by using being deployed in actual-global settings, where it may drastically enhance visitors safety and make a contribution to the reduction of visitors violations, in the long run leading to safer roads and progressed city mobility.

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