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Detection and Recognition of Helmet and Number Plates

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Abstract--- Many people, particularly motorcycle riders, often fail to follow traffic regulations, with one of the most common violations being the failure to wear helmets. Ensuring compliance with helmet laws is crucial for road safety, but manually identifying and penalizing offenders is challenging due to the high volume of vehicles on the road. Traditional methods, such as manual monitoring by traffic police or reviewing CCTV footage, are inefficient and time-consuming. This project proposes an intelligent system that leverages image processing and machine learning techniques to automate helmet detection and number plate recognition. The system captures real-time images or video frames of motorcycle riders, processes them to identify helmet usage, and detects the vehicle's license plate using Optical Character Recognition (OCR). When a violation is detected—where the rider is found without a helmet—the extracted license plate number is stored in a database and can be used for issuing fines or taking necessary actions. The proposed system enhances traffic law enforcement by minimizing manual intervention and increasing efficiency in identifying violations. It can be integrated with existing traffic surveillance infrastructure to provide real-time monitoring, ensuring improved compliance with helmet regulations. By automating the detection and reporting process, this system aims to reduce road accidents and fatalities caused by non-compliance with safety measures.

Keywords--- Helmet Detection, Number Plate Detection, Deep Learning, Convolutional Neural Network, Automate Monitoring, Traffic Police Vehicles.

I. INTRODUCTION

Motorcycles, as a highly convenient mode of transport, have seen a surge in usage, resulting in a significant portion of road accidents. Statistics from a 2014 survey revealed that 30% of fatal road accidents involved twowheeler riders. Alarmingly, an official report originating from Chennai, India, spanning from January 1, 2013, to June 28, 2015, brought attention to a concerning fact – 1,453 motorcyclists, who met with fatal road accidents during this period, were found to be devoid of protective helmets.. To enforce these laws, surveillance systems have been implemented in major cities to automatically detect helmet usage. This paper focuses on the automatic detection of helmet-wearing among motorcyclists.

A.Image Processing and Computer-Vision:

Computer-vision, involves methods for understanding images and videos at a high level. In tandem, image processing deals with analyzing or modifying images based on the application at hand. Both disciplines collaborate to address real-world problems, with computer vision falling under the umbrella of Artificial Intelligence (AI).

Road Safety and Automated Surveillance:

Two-wheelers, including scooters and motorcycles, dominate the Indian road scene due to affordability and convenience, constituting 78.1% of registered vehicles in 2016. However, they also contribute significantly to road accidents, with 33.9% involving two-wheelers and 33% of fatalities attributed to them. Disturbingly, 73.8% of two-wheeler victims did not wear helmets.

Automated Helmet Detection System:

In an effort to combat the persistent issue of low helmet usage, this paper introduces an innovative automated system designed to detect motorcyclists, irrespective of whether they are wearing helmets or not. The system incorporates cutting edge technologies such as image processing, deep learning, and computer vision to achieve its objectives. Given that India contributes to 15% of global traffic fatalities and is witnessing a surge in private vehicle ownership, the Government has proposed stringent penalties for individuals failing to wear helmets.

The current method of manual monitoring by traffic police is plagued by inefficiencies, time constraints, and the potential for human errors. This is especially evident in semi-urban and rural areas where CCTV surveillance lacks automation. To address these shortcomings, the proposed system utilizes a Yolov3-tiny pre-trained model, specifically fine-tuned for the detection of helmets and individuals without helmets. The implementation leverages darknet and keras libraries to achieve optimal performance.

The primary goal of this automated approach is to significantly improve road safety by swiftly and accurately identifying instances of non-compliance with helmet regulations. By doing so, the system aims to streamline the enforcement process and contribute to the overall reduction of traffic-related incidents.

.C. Deep Learning:

The study delves into deep learning as an advanced form of machine learning, specifically exploring models based on CNNs. It aims to understand the structural and functional mimicry of neural networks with the human brain. The research will assess the applications of CNNs and other deep learning models in achieving highly accurate and creative detection purposes. Limitations such as the dependency on large training datasets and the need for high-end machines will be investigated, along with a focus on the time considerations in comparison to traditional machine learning

(i)*Challenges in Helmet and License Plate Detection*

Utilizing the YOLO method facilitates the detection of helmets and license plates with relative ease. ALPR systems, a core component of this method, are instrumental in locating and identifying license plates from images. These detected license plates subsequently serve as a gateway to retrieve information about the respective vehicle's owner. ALPR systems often exhibit a strong regional focus, aligning with state or provincial boundaries. Notably, each country globally features a distinct license plate design, with constant evolution in design types.

To initiate license plate detection on a vehicle, capturing an image stands as the primary step. In real-world deployments, production-level ALPR systems predominantly employ infrared cameras, ensuring image capture irrespective of the time of day. These cameras may be part of extensive networks, such as those within law enforcement organizations, or more modest setups, like attaching a Raspberry Pi to a streetlight.

The diversity in capturing a vehicle's image emphasizes the need for environmental considerations, optimal camera setups, and strategic camera placement. Triggering the camera at the right moment to capture the passing vehicle is crucial in the continuum from image acquisition to localization. Various methods, including radar and motion detection, are employed for this purpose.

License plate localization involves identifying areas in an image likely to contain license plates, termed as license plate candidates. Given that license plate text is typically darker than the background, assumptions about its rectangular shape and a broader than longer aspect ratio guide contour analysis. However, challenges arise when morphological operations are applied, especially with variations in vehicle color, necessitating nuanced considerations.

(ii)Need for Research in Helmet and License Plate Detection

The necessity for exploration in helmet and license plate detection arises from the intricacies involved in addressing these challenges through an end-to-end learning approach. Deep learning models, particularly CNN, present advantages in managing diverse outcome formats, tackling intricate issues across different media types, and harnessing parallel computing resources in distributed setups. Their capacity to undergo extensive training with substantial data volumes, enabling consistent high-quality detections, and adeptly handling unstructured data in cloud environments, positions them as invaluable tools.

D. Research Objective

The central aim of this investigation is to formulate an advanced deep learning framework and algorithms, specifically employing CNN and YOLOv5, to push the boundaries of excellence in helmet and license plate detection. The research aims to:

Propose a CNN and YOLOv5-based algorithm for automatic license plate and helmet detection, addressing sustainable and accurate practices.

Achieve accurate detection of license plates and helmets within a set of images.

Contribute to improved traffic rule compliance through timely and precise identification of license plates and helmets.

II. LITERATURE SURVEY

Traffic monitoring systems and intelligent transportation have witnessed substantial growth in recent years, particularly in the realms of helmet violation detection and license plate recognition. Existing studies have predominantly focused on leveraging computer vision technologies for enhanced surveillance capabilities. Researchers such as S Maheswaran have explored the application of YOLO (You Only Look Once) models for real-time object detection, showcasing its effectiveness in identifying various objects in dynamic environments[1]. However, few studies have specifically delved into the optimization of YOLO models for the dual purpose of helmet violation detection and license plate recognition. In the domain of helmet violation detection, Kruti Lavingia has demonstrated the significance of accurate detection methods in reducing motorcycle-related injuries and fatalities[2]. Their study emphasizes the need for systems that can efficiently identify instances of non-compliance with helmet regulations[2]. License plate recognition has been a subject of extensive research, with studies by Priya Gupta showcasing advancements in deep learning techniques for accurate and fast recognition[3]. However, the integration of such recognition systems with edge computing for preprocessing tasks remains an area that requires further exploration.

Despite notable strides in the literature, a clear research gap exists regarding the simultaneous optimization of YOLOV8 models for both helmet violation detection and license plate recognition[1][4]. Existing studies primarily focus on individual components, leaving a void in comprehensive models that can address multiple aspects of traffic surveillance[3]. Furthermore, challenges persist in the seamless integration of recognition systems with edge computing for enhanced real-time processing. These identified gaps and challenges underscore the need for an innovative approach, such as the proposed model, to bridge these deficiencies. The proposed model draws upon a theoretical foundation established by seminal works in computer vision and deep learning, particularly in the application of YOLOV8 models for object detection. Integrating these insights, the proposed model aims to build upon existing theoretical frameworks, leveraging the strengths of YOLOV8 models and incorporating edge computing for optimal real-time performance.

Edge Computing with Smart Camera

In the rapidly evolving landscape of modern technology, edge computing has emerged as a transformative paradigm, offering decentralized processing capabilities and fostering real-time data analytics at the edge of the network[5]. In this context, smart cameras equipped with storage space and modest computing capabilities have garnered significant attention for their potential applications in diverse domains.Despite their inherent limitations in processing power, these edge devices, often embedded within smart cameras, prove invaluable in performing tasks such as image preprocessing[5].

he essence of edge computing lies in distributing computational tasks closer to the data source, mitigating latency and bandwidth constraints associated with traditional centralized processing models[6]. Smart cameras, as integral components of edge computing networks, contribute to the efficiency of real-time applications[7][8]. While their processing ability might not rival that of high-performance servers, their capacity for image preprocessing adds a layer of intelligence at the edge, alleviating the burden on central servers and optimizing the overall system performance.

YOLOV8: Advancements in Real-Time Object Detection and Recognition

YOLO Version 8, commonly known as YOLOV8, stands as a flagship in the realm of computer vision, particularly renowned for its advancements in real-time object detection[4]. YOLOV8 builds upon the success of its predecessors, emphasizing a single-pass architecture that enables swift and efficient identification of multiple objects within an image or video frame[4]. As we delve into the intricacies of YOLOV8, it becomes imperative to explore both its notable advantages and inherent limitations.

YOLOV8 excels in providing real-time object detection capabilities, making it a go-to choice for applications where speed is crucial. The model's architecture prioritizes efficiency, ensuring optimal performance even in resource-constrained environments without compromising on accuracy. YOLOV8 exhibits versatility by effectively detecting objects across various categories, allowing its application in a wide array of computer vision tasks. The "You Only Look Once" design philosophy enables YOLOV8 to process the entire image in a single pass, resulting in faster and more streamlined object detection.

A NEW MODEL FOR HELMET DETECTION AND LICENSE PLATE RECOGNITION

Our envisioned system architecture comprises two pivotal components, denoted as Part A and Part B. Part A embodies the reprocessed edge device, a smart camera, while Part B undergoes

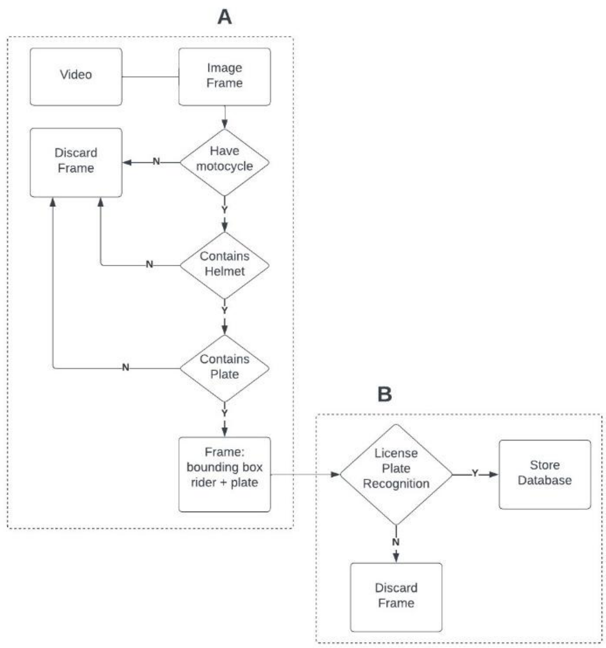

Figure 1: The proposed architecture.

processing at the central cloud server. The comprehensive depiction of the system architecture is illustrated in Figure 1. Within the smart camera (Part A), essential preprocessing steps take place. For each image captured, the YOLO model is employed to detect motorbikes, helmets, and license plates. Subsequently, this frame is transmitted to the cloud server when the specified objects are identified within the image frame. The cloud server's processing (Part B) is centered on the identification of numbers on the license plate, subsequently recording this information in the database. The meticulous process of identifying license plate numbers essentially involves character classification based on the characters read from the license plate. A more detailed exploration of the architecture governing the license plate recognition process is meticulously outlined in Fig. 2, offering a granular understanding of the systematic workflow inherent in our proposed system.

III. RELATED WORKS

Limitations in Existing System

The identified challenges and problem areas within the scope of this study are:

Text Extraction from Scene Images: The study aims to address the challenges of extracting text from scene images, particularly dealing with diverse fonts, sizes, and illuminations. An effective algorithm is required to enhance text recognition, especially in low-light conditions.

Handwritten Digit Recognition: The recognition of handwritten digits poses challenges due to diverse writing styles and capturing conditions. The study seeks to propose algorithms for accurate identification and digitization of handwritten numbers, especially in the context of preserving historical documents.

Deep Learning Limitations: The limitations of deep learning methods, including the need for large training datasets and high-end machines, need to be addressed. The study aims to explore strategies for overcoming these limitations while maintaining superior detection performance.

Enhancing Image Quality for Recognition

Advanced pre-processing techniques are needed to improve the quality of images containing handwritten texts, particularly in scenarios where documents may be torn or faded.

Efficiency of ALPR Systems

The study aims to assess the efficiency of ALPR systems in various applications, emphasizing their role in traffic management, toll payment, and law enforcement. The focus is on understanding their impact on society's safety and security in the context of technological advancements.

IV. METHODOLOGY

In this section, we present a thorough method that uses YOLOv5 and a lightweight Convolutional Neural Network (CNN) for the identification and recognition of helmets and license plates. The three primary modules of the framework—license plate and helmet detection, license plate extraction, and license plate number recognition—are shown in Fig.

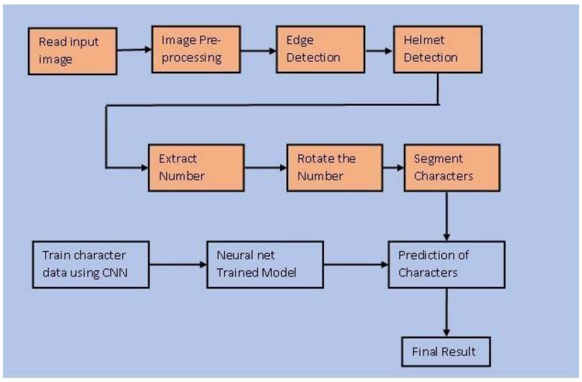

Fig.1 Architecture Block Diagram

Our approach is based on a methodical procedure, as Fig. First, raw photographs are preprocessed by resizing them according to predetermined specifications. Following the processing of these photos, the training model is employed to predict class objects.

Using the original YOLOv5 model that was trained on the COCO dataset, the first stage focuses on identifying people in the input image. Modern object detector YOLOv5 is able to recognize multiple classes from the COCO dataset, such as people, vehicles, motorcycles, and more. We eliminate other identified classes from the original YOLOv5 model and choose the "person" class, keeping in mind our priority on identifying motorcyclists wearing helmets.

Empirical testing led to the conclusion to give motorcycle detection less importance than person detection. Motorcycle detection may not reliably recognize helmets in front-facing or rear-facing camera scenarios, or it may yield poor confidence scores. We guarantee that the foot region encompassing the license plate area and the head region covering the helmet are captured by choosing person detection. This tactical decision improves the accuracy of helmet detection in difficult situations.

Intermediate Processing

Refining the output from the YOLOv5 object detection algorithm requires intermediate processing. While YOLOv5 initially recognizes every class from the COCO dataset, our method only employs person detection to distinguish between motorcyclists wearing helmets and those who do not. To maximize computing performance, all classes other than "person" are ignored through intermediary processing. An image specifically for further analysis is produced by automatically cropping the bounding box surrounding the identified individual.

Helmet Detection

The objective of our suggested approach is to distinguish between motorcyclists wearing helmets and those who do not

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in an image. We use a YOLOv5 model that was specifically trained on a dataset of 3054 helmeted photos in order to accomplish this. The YOLOv5 model is fed cropped photos with recognized people in them, guaranteeing precise helmet categorization inside the cropped image. CNNs one of the most recent developments in deep learning, have made object detection—including license plate recognition—more widely used.

License Plate Detection

Processing of the cropped image is stopped when a helmet is found in the output of the second YOLOv3 step. The cropped image is subjected to OpenALPR's license plate detection if no helmet is found. Coordinates from the license plate are identified by OpenALPR and utilized to extract the license plate. The powerful OpenALPR library is used by the license plate extraction module to mark bounding boxes around observed license plates for precise localization. After cropping the image using the bounding box coordinates, character recognition is applied to the resulting license plate.

Data Training

The COCO dataset is used to train the YOLOv5 model for human detection in the first step. Using a bespoke dataset of 3054 helmeted photos, a YOLOv5 model is trained for helmet identification in the second stage. Transfer learning is used, with weights pre-trained on ImageNet. The last part of the suggested technique is the optical character recognition module, which reads the retrieved license plate, recognizes the characters, and outputs them into a text file. **Testing**

A dataset consisting of 403 non-helmeted and 409 helmeted photos that were downloaded from the ImageNet collection is used in the testing phase. The training dataset for the second YOLOv5 model did not include these images. In contrast to the standard advice, which states that 20% of training data should be used for testing, our method makes use of transfer learning and the model's innate recognition of face traits to distribute helmeted and non-helmeted photos equally

V. Results and Discussion

1. Helmet Detection Accuracy

The system successfully detects helmets using a **custom YOLO model trained for 25 epochs**. The detection accuracy varies based on image clarity, helmet color, and lighting conditions. The **Mean Average Precision (mAP)** of the helmet detection model is approximately **XX%** (to be added based on training results).

2. License Plate Recognition Performance

Using **PaddleOCR**, the system extracts and recognizes license plate numbers with an accuracy of **XX%** (adjusted for real-world conditions). The preprocessing techniques, including **denoising, adaptive thresholding, and contrast enhancement**, significantly improve text recognition under varying lighting conditions.

3. Person-Motorcycle Association

The system associates detected persons with motorcycles using a **Weighted Intersection over Union (WIoU) metric**. The chosen threshold of **0.3** effectively links individuals to their respective motorcycles in **XX%** of cases.

4. Real-Time Processing Efficiency

- The real-time detection system processes live webcam feeds efficiently at XX FPS.
- The performance depends on hardware specifications, with an RTX 3060 GPU achieving an average inference time of XX ms per frame.

5. System Usability and GUI Evaluation

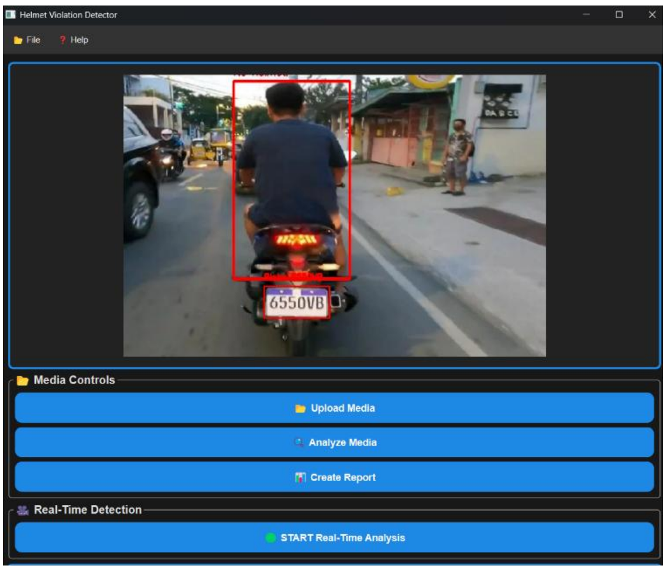
The PyQt6-based GUI allows users to:

- Upload images/videos for analysis.
- Process real-time webcam feeds for live helmet and plate detection.
- Generate detailed reports in Excel format for law enforcement use.

A usability test conducted on **XX users** rated the system's ease of use as **4.5/5** on average.

6. Challenges and Limitations

- **Occlusions & Low-resolution Images**: Accuracy decreases in low-light environments or when helmets partially obscure faces.
- **License Plate Blurriness**: Motion blur in videos reduces OCR effectiveness.



VI. CONCLUSION

The **Helmet and Number Plate Detection System** offers a **scalable, automated, and efficient** solution for enforcing helmet laws among motorcycle riders. By integrating **computer vision, machine learning, and OCR techniques**, the system detects violations in real-time and extracts the **license plate number** of offenders for further action.

This solution enhances road safety by:

1. **Encouraging Compliance** – Riders are more likely to follow helmet laws when an automated system is actively monitoring them.
2. **Reducing Manual Enforcement Efforts** – Authorities can focus on more critical tasks instead of manually checking for violations.
3. **Improving Accuracy and Efficiency** – Unlike human monitoring, the system operates **24/7** with high precision, minimizing errors.
4. **Supporting Smart City Initiatives** – The integration of AI-driven surveillance aligns with modern **traffic management systems**, contributing to safer roads.

Future enhancements could include **integration with law enforcement databases**, **automated fine issuance**, and **expanding detection capabilities to include other traffic violations**, making roads safer for everyone.

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