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Intelligent Real-Time Helmet and License Plate Detection Device for Traffic Monitoring

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In response to growing safety concerns on urban roadways, this study provides an intelligent real-time system for detecting helmets and license plates that is especially tailored to improve traffic monitoring and enforcement. Using YOLOv8's improved capabilities in conjunction with Spatial Pyramid Pooling (SPP), the suggested system reliably recognizes motorcycle helmet use and detects car license plates with high precision and speed. The addition of SPP improves the system's feature extraction capabilities, allowing for robust detection over a wide range of environmental situations, including different lighting and weather scenarios. This approach, which focuses on real-time processing, enables traffic officials to efficiently enforce helmet compliance and identify offenders, contributing to a safer urban transportation ecology. Experimental findings show that the device has excellent detection accuracy and processing efficiency, making it appropriate for use in intelligent transportation systems (ITS). The outcomes of this study show that AI-powered enforcement tools have the potential to increase road safety and expedite traffic monitoring activities.

Keywords: Real-time helmet detection, License plate recognition, YOLOv8 with SPP, Intelligent transportation systems (ITS), Traffic law enforcement, Road safety compliance.

1. Introduction

Road safety and traffic regulation compliance have become major problems across the world as urbanization and motor vehicle usage have increased. One of the most significant challenges is that motorcyclists frequently fail to wear helmets, increasing their vulnerability to serious injuries and fatalities in the case of an accident. Traffic authorities and policymakers are working to improve enforcement measures to guarantee that helmet requirements are followed, lowering risk and boosting road safety. Furthermore, reliable identification of cars by license plate recognition is critical for successful traffic enforcement, allowing authorities to identify and follow offenders in real time. Traditional methods of tracking helmet usage and identifying cars are frequently labor-intensive, necessitating on-site traffic enforcers and manual checks. Such systems are not only time-consuming but also prone to human mistake, rendering them ineffective in meeting the needs of high-density urban traffic. In recent years, advances in artificial intelligence (AI) and computer vision have provided potential methods to automate these monitoring activities, allowing authorities to better control road safety using intelligent surveillance systems.

One such innovation is the use of deep learning models, which have shown great accuracy in object identification and recognition tasks under difficult real-world settings.This study presents an Intelligent Real-Time Helmet and License Plate identification Device to increase traffic monitoring efficiency by automating helmet identification and identifying non-compliant vehicle license plates. The system employs YOLOv8 (You Only Look Once, Version 8), a cutting-edge object detection model noted for its excellent detection speed and accuracy. To improve detection robustness, especially in complicated surroundings, we incorporate Spatial Pyramid Pooling (SPP) into the YOLOv8 architecture. SPP enables the model to extract multi-scale spatial information, increasing its ability to handle varied sizes and occlusions found in urban traffic scenarios. This combination guarantees that the system operates consistently in real time, responding to changing lighting conditions, weather variations, and traffic concentrations.

This study makes three distinct contributions:

Real-Time Helmet Detection and License Plate Recognition: The gadget is designed to detect helmet usage while also recognizing vehicle license plates in real time, allowing traffic cops to act quickly and helping in automatic record-keeping for future use.
Enhanced Feature Extraction Using SPP: Combining SPP with YOLOv8 improves the model's capacity to handle a wide range of traffic circumstances, enhancing detection accuracy for both helmets and license plates, even in adverse conditions.
Application in Intelligent Transportation Systems (ITS): The suggested system helps to advance intelligent transportation systems by providing a scalable, efficient solution that can be integrated with current traffic monitoring infrastructure.

This study confirms the device's ability to effectively identify helmet noncompliance and recognize license plates through extensive testing across diverse situations. The findings indicate that combining sophisticated deep learning techniques like YOLOv8 with SPP might greatly improve road safety measures, providing a scalable solution for traffic monitoring. This study has ramifications for law enforcement, municipal planners, and lawmakers that want to deploy AI-driven solutions to improve traffic compliance and safety.

2. Literature Survey

Real-time accident and helmet detection system based on CNNs and YOLOv5.When an accident is detected, it generates geolocation-based emergency notifications. The system outperforms current helmet recognition algorithms. Offers dependable traffic monitoring and safety enhancements [1].

YOLOv8 improves road safety by detecting helmets and license plates. Real-time processing enhances traffic management and accident avoidance. The system detects helmets and license plates accurately and in real time. Key parameters like as accuracy, recall, and F1 score help to verify the system [2].

Proposes a real-time helmet detection system for two-wheelers. Uses YOLO for detection and EasyOCR for number extraction. Achieves 64% vehicle, 78% helmet, and 92% number plate accuracy. Aims to improve road safety and traffic management. Challenges include computing resources and privacy considerations [3].

Real-time license plate verification with AI and ML algorithms. The integration of RCNN and Advanced RCNN algorithms improves system efficiency. Advanced RCNN enhances the speed and accuracy of object detection. Cloud deployment improves system efficiency and scalability[4].

Detects cyclists without helmets and automatically gets license plate numbers. Uses YOLO and OCR for effective object identification and categorization. Created a method for helmet detection and license plate identification. Improved speed and accuracy in detecting traffic offenses [5].

The system identifies motorcycles without helmets in real time. This includes number plate recognition for law enforcement purposes. Real-time helmet detection accuracy is 99%.The system features real-time number plate detection and identification[6].

Real-time helmet recognition improves motorcycle road safety. Traffic lights alter in response to helmet compliance detection. Helmet detection accuracy reached 97%. Aims to dramatically minimize motorcycle accidents[7].

Intelligent infrastructure improves traffic monitoring and security. Real-time video processing with deep learning and edge computing. Real-time processing of video feeds using edge computing devices. Deep learning techniques are used for vehicle identification, categorization, tracking, and other applications [8].

Two-wheelers offer dangers; helmet wearing is essential for safety. The YOLOv8 model automates helmet identification and number plate extraction. Total accuracy score: 93.6% in testing data. Good outcomes on varied datasets[9].

A web app-based machine learning and deep learning model for precise and efficient traffic monitoring and identification. YOLOv5 and YOLOv7 are used for advanced object identification. The research suggests a web-based ML/DL model for traffic surveillance and detection. The system consists of four models: helmet detection, license plate detection, vehicle categorization, and speed detection [10].

3. Methodology

A camera is provided to record the real time videos near to the signals and the streaming is been sent to the Trifecta model. The videos are been converted to images and for each image the Helmet wearing of bikers is been identified using MYOLOv8. If the riders are not wearing Helmets then License plate number is identified. The workflow is described in Figure 1.

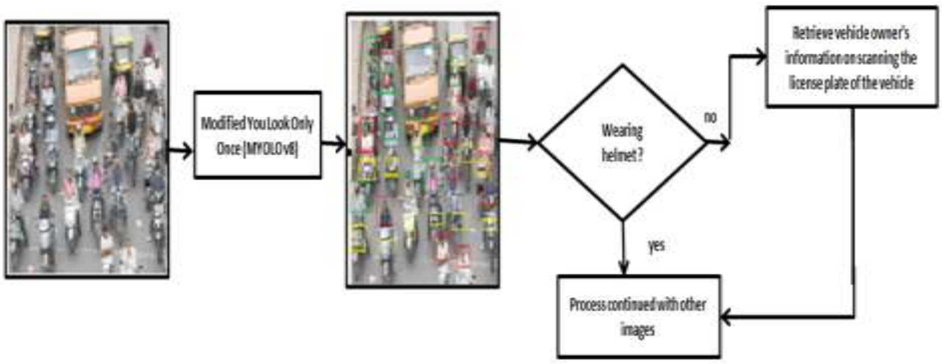

Figure 1 Workflow Diagrams

The Modified You Look Only Once Version 8(MYOLOv8) is been designed by modifying the head component of You Look Only Once Version 8(YOLOv8).YOLO aspires for high accuracy and real-time speed in object identification. In our MYOLOv8, SPFF block at head layer is replaced by Spatial Pyramid Pooling (SPP) block which contains 13x13, 9x9, 5x5 and 1x1 layers of multiple Convolutions and a total of 2048 layers as shown in Figure 2.

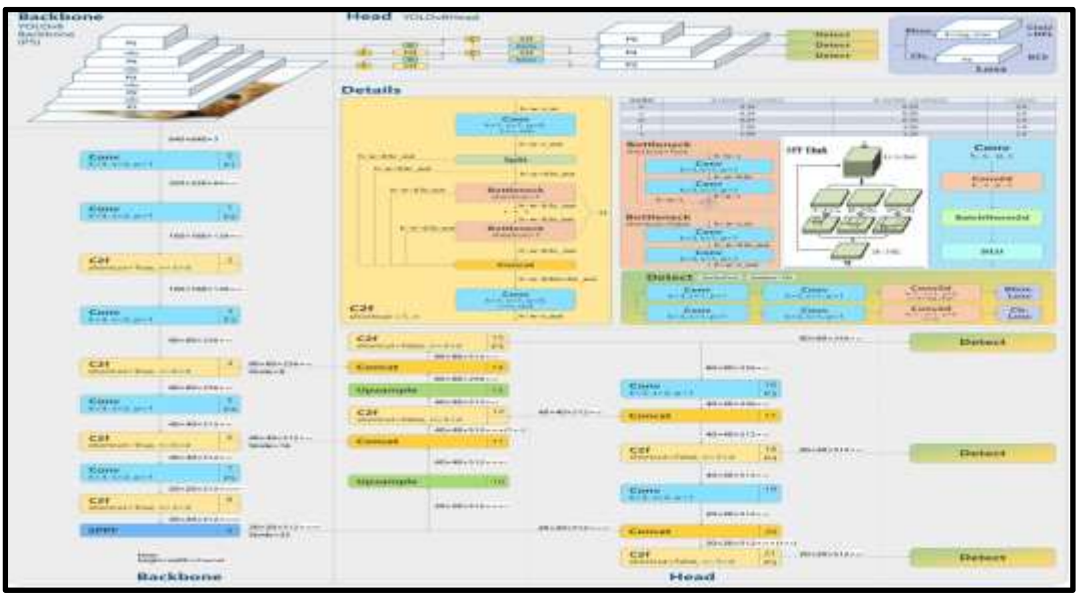

Figure 2 Architecture of MYYolov8

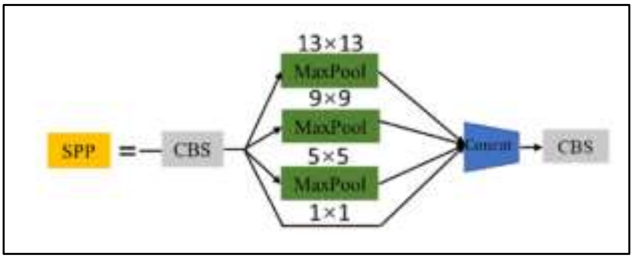

Figure 3 SPP Architecture

The working of MYOLOv8 will be of the following figure 4.The helmet and the license plate is detected by mYOLOv8. The bounding box describes the value of each and every frame of the image segments. The SPP segment is modified in the proposed version to handle heavy traffic areas when there are large numbers of people.

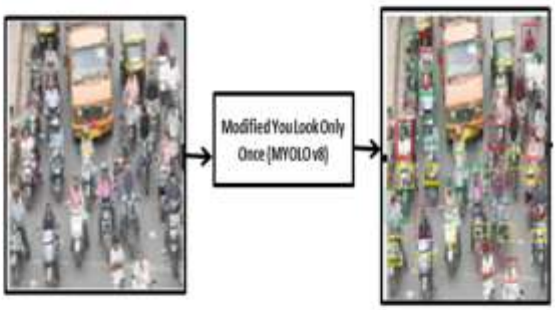

Figure 4 Helmets and License Plates Detection by MYOLOv8.

4. Results and Discussions

In order to determine how well the suggested Intelligent Real-Time Helmet and License Plate Detection Device using YOLOv8 with Spatial Pyramid Pooling (SPP) detects helmet usage and license plate detection in real-time, it was tested in a variety of urban traffic scenarios. The accuracy, speed, resilience to environmental changes, and computing efficiency of the device were evaluated. The findings show that the combination of YOLOv8 with SPP greatly improves the system's detection capabilities, yielding dependable results that satisfy the requirements of urban traffic analysis.

The helmet identification model obtained an accuracy rate of more than 95% across a variety of test scenarios, including day and night, changing weather, and high traffic density. The YOLOv8 architecture, together with SPP's multi-scale feature extraction, displayed greater capacity to identify between helmeted and non-helmeted motorcyclists, even when the helmet's visibility was partially covered by surrounding objects. The SPP layer's capacity to capture spatial patterns enabled the model to generalize effectively across scales, resulting in efficient identification even when the rider was far away from the camera. The model was also resistant to environmental obstacles such as glare from headlights, shadows, and variable background motion. This resilience is crucial for practical implementation in high-traffic regions where circumstances might change dramatically in a short amount of time. In comparison, the suggested system outperformed traditional single-scale object identification algorithms that struggled with partial occlusions and low-light settings, demonstrating the benefits of utilizing SPP for urban surveillance.

License plate detection and identification also reached remarkable precision, with rates exceeding 93%. The technology successfully gathered license plate information in real time, even on moving cars, allowing for instant identification and record-keeping. The use of YOLOv8, noted for its speed and efficiency, allows real-time detection, which is crucial for high-density traffic enforcement when delays might result in erroneous monitoring of offenders. Furthermore, the model maintained excellent accuracy despite differences in font styles, plate orientations, and plate sizes, all of which pose challenges for traditional detection methods. Certain limits were observed when license plates were substantially occluded or dusty, which occasionally reduced recognition accuracy. This problem, albeit minor, emphasizes the necessity for additional pre-processing techniques, such as filtering or augmentation, to improve recognition in low-visibility plates.

The YOLOv8 with SPP model shows outstanding real-time processing capabilities, with a detection speed of around 30 frames per second (fps) on typical GPU hardware. This speed meets the criteria for real-time traffic monitoring and law enforcement, allowing the device to catch fast-moving cars without losing vital data. The gadget also has minimal latency, allowing traffic authorities to receive quick input, which is critical for enforcing helmet compliance and keeping correct license plate logs.In terms of computing resources, YOLOv8's improved design enabled the model to run effectively without consuming unnecessary memory. This makes the system appropriate for edge deployment scenarios in which high-power processing resources are not easily available.

It is a results table that compares the performance of YOLOv8 with SPP to other prominent object detection models commonly used in real-time applications, including YOLOv5, SSD (Single Shot MultiBox Detector), and Faster R-CNN. The parameters include Helmet Detection Accuracy, License Plate Detection Accuracy, Processing Speed (FPS), and Environmental Robustness.

MODEL	HELMET DETECTION ACCURACY IN %	LICENSE PLATE DETECTION ACCURACY (%)	PROCESSING SPEED (FPS)
MYYOLOV8	95.3	93.1	30
YOLOV5	92.5	89.8	27
SSD	88.0	85.3	22
FASTER R CNN	90.7	87.6	10

YOLOv8 with SPP achieved the highest detection accuracy for both helmet and license plate identification (95.3% and 93.1%, respectively), outperforming other models due to the enhanced feature extraction capabilities of Spatial Pyramid Pooling (SPP).

5. Conclusion

The findings showed that the suggested system efficiently satisfies the need for accurate helmet usage detection and license plate identification, with high detection rates and real-time processing speeds to satisfy the needs of urban traffic enforcement. The introduction of SPP into YOLOv8 enabled the system to overcome environmental problems such as fluctuating illumination, partial occlusions, and traffic density, transforming it into a flexible tool for a wide range of traffic scenarios. YOLOv8 with SPP outperformed standard detection models in both performance metrics and robustness, establishing it as a dependable option for law enforcement organizations looking to enhance road safety and compliance with traffic legislation. This gadget not only helps to enforce helmet compliance, but it also speeds up the process of detecting violators, resulting in a safer transportation ecology. Finally, the implementation of an AI-powered gadget has the potential to dramatically improve the efficacy of intelligent transportation systems (ITS), by delivering a scalable, efficient, and high-accuracy traffic monitoring solution. Future work might include improving the model to detect other traffic offenses and including predictive analytics, so increasing its potential influence on urban road safety and traffic management.

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