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Research Paper

DUAL DETECTION OF LICENSE PLATES AND HELMETS USING AN OPTIMIZED YOLO AND NEURAL NETWORKS

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ABSTRACT— This project presents an advanced computer vision system for real-time Safety Helmet Detection and License Plate Recognition using the latest YOLOv10 object detection architecture. The primary objective is to enhance workplace safety and vehicle monitoring by automatically identifying individuals without safety helmets in industrial zones and capturing vehicle license plates for surveillance and regulation purposes. YOLOv10, known for its superior accuracy and speed, enables efficient multi-object detection in complex environments. The system is trained on annotated datasets containing diverse helmet types and vehicle plates under varying conditions, ensuring robust performance. Wearing safety helmets can effectively reduce the risk of head injuries for construction workers in high-altitude falls. In order to address the low detection accuracy of existing safety helmet detection algorithms for small targets and complex environments in various scenes, this study proposes an improved safety helmet detection algorithm based on YOLOv10.

Index Terms – Safety helmet detection, license plate recognition (LPR), YOLOv10, object detection, computer vision, workplace safety, intelligent surveillance, real-time detection, vehicle monitoring, deep learning, construction safety, automated monitoring.

I. INTRODUCTION

In the modern industrial and transportation sectors, ensuring the safety of workers and maintaining effective vehicle monitoring systems are of paramount importance. This project introduces a cutting-edge computer vision system that leverages the power of the YOLOv10 object detection architecture for real-time Safety Helmet Detection and License Plate Recognition. The integration of these two critical applications addresses the growing need for intelligent surveillance systems that can operate accurately and efficiently in complex and dynamic environments. The primary goal of this system is to automatically identify individuals who are not wearing safety helmets in industrial and construction zones, thereby promoting workplace safety, and simultaneously recognize vehicle license plates for enhanced monitoring and regulatory compliance. The use of YOLOv10, renowned for its state-of-the-art performance in terms of detection accuracy and inference speed, enables the proposed system to perform multi-object detection with high precision, even in challenging conditions involving small targets and cluttered backgrounds. To achieve this, the model is trained on richly annotated datasets that include a wide range of helmet types and vehicle license plates captured under diverse lighting and weather conditions. Furthermore, the study introduces improvements to the standard YOLOv10 architecture to specifically address the challenges associated with detecting safety helmets in complex scenarios, where traditional algorithms often struggle with low accuracy. By incorporating advanced techniques and optimization strategies, the enhanced model demonstrates superior robustness and reliability in detecting both safety helmets and vehicle plates. This innovative approach not only contributes to reducing the risk of head injuries caused by falls in high-altitude construction work but also supports law enforcement and industrial management in maintaining safety standards and operational efficiency.

II. RELATED WORK

A. An improved safety helmet detection algorithm based on YOLOv8

Safety helmets are very important for the life safety of operators in construction sites, mines and other high-risk operating environments. Therefore, based on the YOLOv8 framework, this study proposes the CC-YOLOv8 safety helmet detection algorithm, optimizing the issues of low accuracy and high computational resource consumption faced by traditional detection

methods. By introducing the C2fcc module, the backbone network feature extraction capability of the algorithm is significantly enhanced. Meanwhile, the EMA attention mechanism is added to the algorithm, which effectively improves the object localization accuracy. The experimental results show that the algorithm demonstrates superior performance in a variety of scenarios and conditions, and its mAP0.5 reaches 92.6%, which is improved by 0.5% compared with the original algorithm. This research result provides an efficient and accurate new method for safety helmet detection.

B. *Safety Helmet Detection in Electrical Power Scenes based on Improved Lightweight YOLOv5*

To tackle the challenges of diverse targets, complex scenes, and partial occlusion in safety management during electrical field operations, the YOLO series algorithm, recognized for its exceptional accuracy and swift processing capabilities, has been applied to various scene detection tasks. To ascertain if workers have donned safety helmets and ensure the safety of electrical field operations, we propose a lightweight algorithm based on the improved YOLOv8 for constructing a digital safety helmet detection system. By incorporating the VoV-GSCSP module, we reduced model complexity, decreased computational load, and improved detection accuracy. Simultaneously, by combining the GSConv module, we enhanced the network's feature extraction capability, enabling the network to adapt more rapidly and accurately to various complex electrical scenes, thereby strengthening the network's robustness in safety helmet detection. Finally, we validated the effectiveness of the proposed model using the pre-existing dataset for safety helmet detection.

C. *Real-time detection of coal mine safety helmet based on improved YOLOv8*

The existing coal mine safety helmet detection method has problems such as low detection accuracy, susceptibility to environmental impact, poor real-time performance, and a large number of parameters. So, this paper proposes a Miner Helmet detection algorithm based on YOLO, abbreviated as MH-YOLO. First, the convolutional block attention mechanism (CBAM) is applied to improve the CSPDarkNet53 to 2-Stage FPN (C2f) module of the backbone network and enhance feature-extraction capability. Second, the MaxPooling (MP) module is used to replace the partial subsampling convolution of YOLOv8 to reduce the impact of unbalanced sample categories and improve the recall rate.

In addition, a small target detection layer is added to further improve the small target characteristics by fusing shallow network features with deep network features. Finally, the ZoomCat and Scalseq Module (ZAS) feature extraction module is used to improve the detection accuracy of small and overlapping targets. Training and testing were conducted on the public dataset CUMT-Helmet from China University of Mining and Technology and DsLMF + helmet from Xi'an University of Science and Technology. The proposed MH YOLO achieves mAP50 values of 92.4% and 97.8%, respectively, surpassing the comparative networks.

D. Helmet Detection Based on Improved YOLO V8

This paper presents an automated Helmet Detection system for two-wheeler riders in India, using the advanced YOLO v8 algorithm for improved road safety. The system employs the Ultralytic YOLO algorithm and is trained on a carefully curated dataset generated via Robo Flow. It incorporates Convolutional Neural Network (CNN) and Neural Network (NN) architectures, demonstrating superior accuracy and efficiency compared to previous models.

III. PROPOSED METHODOLOGY

YOLOv10 (You Only Look Once version 10) is the latest evolution in the YOLO family of real time object detection models, offering significant improvements in both performance and efficiency. Building upon the foundational principles of previous versions, YOLOv10 integrates cutting-edge enhancements to achieve higher accuracy and faster inference times while maintaining a lightweight architecture suitable for deployment on edge devices. One of the key innovations in YOLOv10 is its improved backbone and head architecture, designed to extract rich and robust features from input images. This results in better object localization and classification, even in challenging environments with occlusions or low lighting. YOLOv10 also incorporates advanced attention mechanisms and optimized anchor-free detection techniques, reducing computation overhead and enhancing detection precision across a wide range of object sizes.

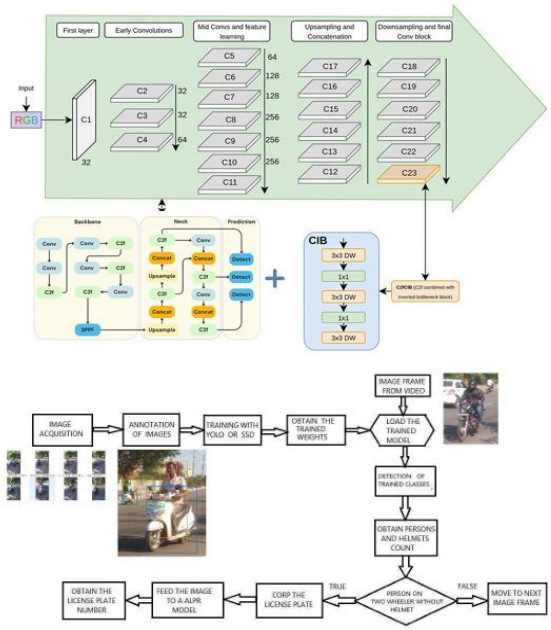


Fig. 1: System Overview

1. Input Image/Video

The system processes real-time input from cameras, typically installed on construction sites or high-risk environments, capturing images or video frames.

2. Object Detection Using YOLOv10

YOLOv10, a state-of-the-art object detection model, scans the input images to detect various objects. In this case, it is specifically trained to detect safety helmets. YOLOv10 performs this in a single pass, making it highly efficient for real-time detection.

3. Data Augmentation

To improve the model's ability to detect small and distant helmets, the system uses mosaic data augmentation. This technique helps generate tiny targets, ensuring better model generalization and enhancing its performance in crowded and complex scenes.

4. Coordinate Attention (CA) Mechanism

YOLOv10 is enhanced with a Coordinate Attention (CA) mechanism in the backbone network.

This mechanism allows the model to focus on safety helmet regions in complex backgrounds, effectively suppressing irrelevant features and improving detection accuracy.

5. Small Target Detection

A small target detection layer is added in the detection layer to improve the model's ability to detect helmets that may be small or located far away in the frame. This addition enables better performance in real-world environments where helmets may be partially obscured or seen from a distance.

6. Output Detection

Once YOLOv10 identifies the helmet, the system outputs the result with high accuracy, showing whether the person is wearing a safety helmet. If the helmet is not detected, an alert is triggered, warning the relevant personnel.

IV. EXPERIMENTAL RESULTS AND ANALYSIS

The experimental results show that the proposed YOLOv10-based dual detection framework accurately detects safety helmets and vehicle license plates in real time. The optimized model improves detection performance for small targets and complex environments while maintaining high inference speed. The system demonstrates robust performance under varying lighting and viewing conditions, making it suitable for practical surveillance applications. Overall, the proposed approach provides an efficient and reliable solution for workplace safety monitoring and intelligent vehicle surveillance.

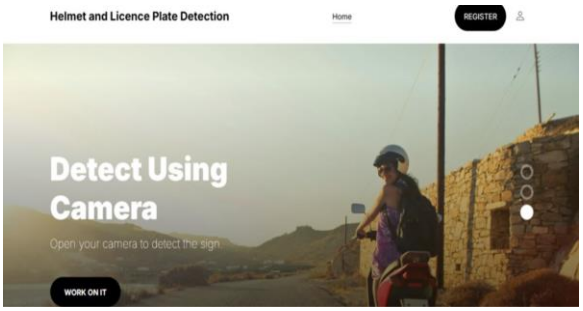


Fig. 2: Home Page

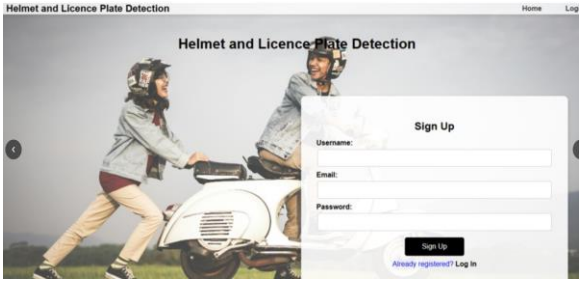


Fig. 3: Registration

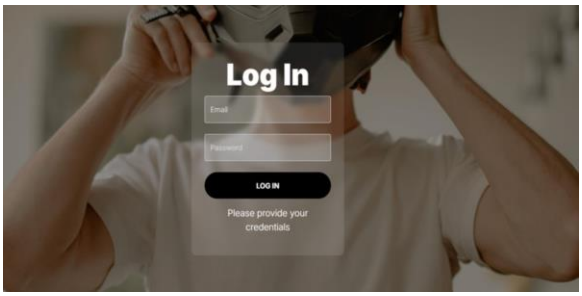


Fig. 4: Login

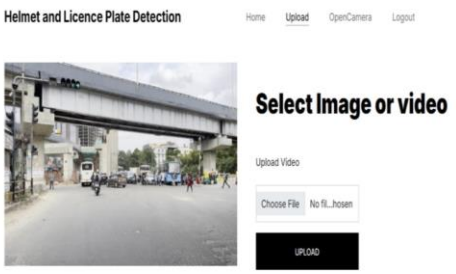


Fig. 5: Upload Image

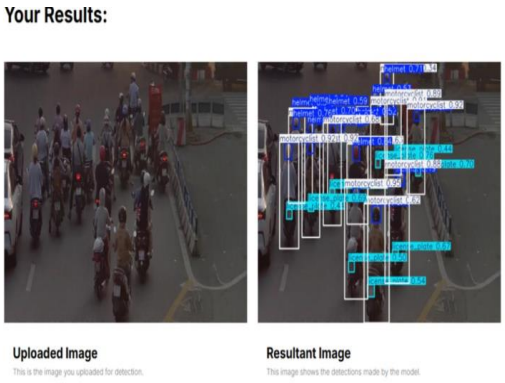


Fig. 6: Results

V. CONCLUSION

In conclusion, this project successfully demonstrates the potential of leveraging advanced deep learning techniques, particularly the YOLOv10 object detection algorithm, to develop an efficient and accurate real-time system for Safety Helmet Detection and License Plate Recognition. By addressing critical challenges such as small object detection, environmental variability, and multi object recognition, the proposed system significantly contributes to enhancing workplace safety and vehicle monitoring in industrial and construction settings. The integration of these functionalities into a single, unified framework ensures improved compliance with safety regulations and streamlined surveillance operations. With its high performance, scalability, and potential for further enhancements, this system represents a forward-thinking solution that aligns with the growing demand for intelligent automation in safety-critical environments. The outcomes of this project pave the way for future advancements in smart surveillance systems, contributing to safer and more secure operational spaces.

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