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Revolutionizing Safety Helmet Detection using YOLOv8 Enhancements

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ABSTRACT: Safety helmets plays a vital role in minimizing head injuries, especially for construction workers operating in hazardous, high-risk environments. However, detecting safety helmets accurately in complex and cluttered scenes remains a significant challenge for current algorithms. To tackle this issue, a refined safety helmet detection method based on the YOLOv8 architecture is introduced. This approach leverages advanced data augmentation techniques to improve the model's recognition of small objects by generating more diverse training samples. The integration of a coordinate attention mechanism into the backbone network allows the model to better distinguish helmet regions from noisy backgrounds, enhancing focus and reducing distractions from irrelevant features. Moreover, a streamlined neck structure is employed to efficiently merge features from various scales while keeping the model lightweight and efficient. A specialized detection layer is also incorporated to strengthen the recognition of smaller targets. Overall, the proposed method demonstrates improved detection accuracy and robustness, offering a more reliable and real-time solution for safety helmet monitoring in dynamic and visually complex environments.

I. INTRODUCTION

In work environments such as construction sites, tunnels, and coal mines, wearing a safety helmet is one of the fundamental requirements to ensure personnel safety. It effectively reduces the risk of head injuries when construction workers fall from heights, providing crucial protection [1], [2], [3]. Monitoring whether individuals are wearing safety helmets as per regulations relies on video data collected by cameras and assessed through manual supervision. However, traditional monitoring methods face increased labor costs, surveillance fatigue, and subjective judgments. Therefore, the development of high-performance safety helmet detection algorithms holds significant importance. Safety helmet detection methods have been enhanced with the continuous advancement of algorithms in computer vision and improvements in computational capabilities. As a highly regarded technology, deep learning has found widespread application in safety helmet recognition. Compared to traditional methods, deep learning algorithms, especially the YOLO series, have achieved a remarkable balance between accuracy and speed [4]. However, Yolo-based safety helmet detection methods still encounter challenges in achieving high accuracy for small targets in complex backgrounds. Complex environments may feature numerous interfering objects, such as buildings and trees, making it difficult for the algorithm to locate and identify safety helmets accurately Additionally, safety helmets' small and monochromatic features make them susceptible to interference from other objects in complex backgrounds, leading to misjudgments. Complex backgrounds may also involve occlusion phenomena, such as overlapping crowds and passing vehicles, causing the safety helmet's shape to be incomplete or partially obscured, making it challenging for the algorithm to identify. Since the introduction of the YOLO single-stage object detection algorithm, it has garnered widespread attention from industry scholars. In recent years, the YOLO algorithm has undergone continuous optimization. In 2023, the Ultralytics team proposed the YOLOv8 version, which, while meeting real-time requirements, exhibits high detection accuracy and a lightweight network structure suitable for object detection. The progress in object detection has inspired the development of safety helmet detection methods using deep learning. Numerous researchers assert that deep learning technology represents a crucial avenue for tackling construction security management challenges. YOLOv8 employs deep learning technology, enabling it to learn and comprehend complex visual features. This capability ensures robust execution of helmet detection tasks under varying lighting, angles, and background conditions. However, the current usage of YOLOv8 in safety helmet detection is limited, and its effectiveness in detecting small targets in complex backgrounds could be better. Therefore, based on the YOLOv8 algorithm, we optimized the model to enhance its accuracy, introducing the novel YOLOv8n-SLIM-CA safety helmet detection algorithm. The main contributions of this paper are as follows substantially boost the algorithm's detection accuracy, this approach utilizes the mosaic data augmentation method. By employing random augmentation and diverse scaling techniques on the dataset, numerous small targets are generated. This deliberate augmentation and unpredictable scaling contribute to strengthening the network's overall robustness. (2) This paper introduces the YOLOv8n-SLIM-CA model. The model incorporates three key enhancements: the integration of a Coordinate Attention (CA) mechanism, the adoption of a Slim-Neck structure, and the addition of a small target detection layer. These improvements collectively strengthen the model's detection capabilities for complex background objects and small targets. (3) The model proposed in this paper is tested on the SHWD dataset in comparison with various algorithms. The results indicate that the algorithm surpasses other algorithms in terms of detection performance. The algorithm exhibits higher robustness in real-world scenarios and across different working environments.

II. LITERATURE REVIEW

In their 2019 paper,Haibin Li[ab],Dengchao Wu[ab],Wenming Zhang discuseed the YOLO-PL: Helmet wearing detection algorithm based on improved YOLOv4. Workplace safety accidents are a pervasive issue worldwide. According to the National Work Safety Supervision Administration, a striking 67.95 % of construction accidents occur due to workers not wearing helmets. Existing helmet-wearing detection algorithms, however, tend to underperform in real-world scenarios where challenges such as smaller helmet areas in images, complex backgrounds, and object occlusions are present. Additionally, these models have a considerable amount of parameters, which impedes their practical deployment. This study proposes a novel, lightweight helmet detection algorithm, YOLO-PL, based on YOLOv4, to address these challenges. Initially, we designed the YOLO-P algorithms. YOLO-P algorithms optimize the network structure by refining its ability to detect small objects and improving the anchor assignment in the detection head. We design the Enhanced PAN (E-PAN) structure to merge the higher-layer, low-noise information with the lower-layer information based on the Path Aggregation Network (PAN). The YOLO-P algorithm improves detection accuracy by using the E-PAN structure.

In their 2023 paper, Sahir Suma, Anoop GL, Mithun BN,discuseed on 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. Ongoing refinements aim to enhance accuracy further and bounding box precision, highlighting the system's potential to significantly improve road safety in India.

In their 2023 paper, X. Wu, D. Hong, Z. Huang, and J. Chanussot discuseed 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.

In their 2024 paper, S Jie Li, Shuhua Xie, Xinyi Zhou, Lei Zhang analyze 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. The detection time is 10.1 ms, enabling accurate and real-time detection of whether coal miners are wearing safety helmets.

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III. METHODOLOGY

The system is organized into key modules, each designed to handle distinct aspects Revolutionizing Safety Helmet Detection Using YOLOv8 Enhancements.The modules are as follows:

- Input Image/Video
- Object Detection Using YOLOv8
- Data Augmentation
- Coordinate Attention (CA) Mechanism:
- Small Target Detection
- Output Detection

3.1.2 Module Descriptions

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 YOLOv8

YOLOv8, 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. YOLOv8 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

YOLOv8 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 YOLOv8 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. EXISTING SYSTEM

In a similar project previously done using OpenCV, safety helmet detection was achieved through image processing and object detection techniques. OpenCV was used to preprocess input images by resizing, converting color spaces, and filtering to improve image quality. Object detection methods, such as Haar cascades, helped identify helmets in the images. Features like edges and contours were extracted to locate the helmets, and bounding boxes were drawn around detected helmets, with labels indicating whether a helmet was worn or not. This approach allowed for real-time video processing, providing immediate feedback. However, it may face challenges in complex environments or with small targets, which is where YOLOv8 can offer improved accuracy and efficiency.

V. PROPOSED SYSTEM

YOLOv8 algorithm is to accurately detect safety helmets in real-time, particularly in challenging environments like construction sites. YOLOv8 serves as the backbone for the detection process by identifying helmets, even when they are small or located at a distance. The algorithm is particularly effective due to its high-speed object detection capabilities, enabling the system to process video frames in real-time. Key features such as the Coordinate Attention

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(CA) mechanism and small target detection layer enhance YOLOv8's performance, allowing it to focus on relevant helmet features while suppressing background noise. This makes YOLOv8 ideal for detecting safety helmets in diverse and complex settings, ensuring worker safety by providing immediate alerts when helmets are not detected.

Proposed System Advantage:

- YOLOv8 includes a specialized layer for small target detection.
- Improved Detection in Complex Environments
- YOLOv8 can handle large datasets and work efficiently in different scenarios
- YOLOv8 is optimized for performance, reducing computational load without sacrificing accuracy.

System Architecture

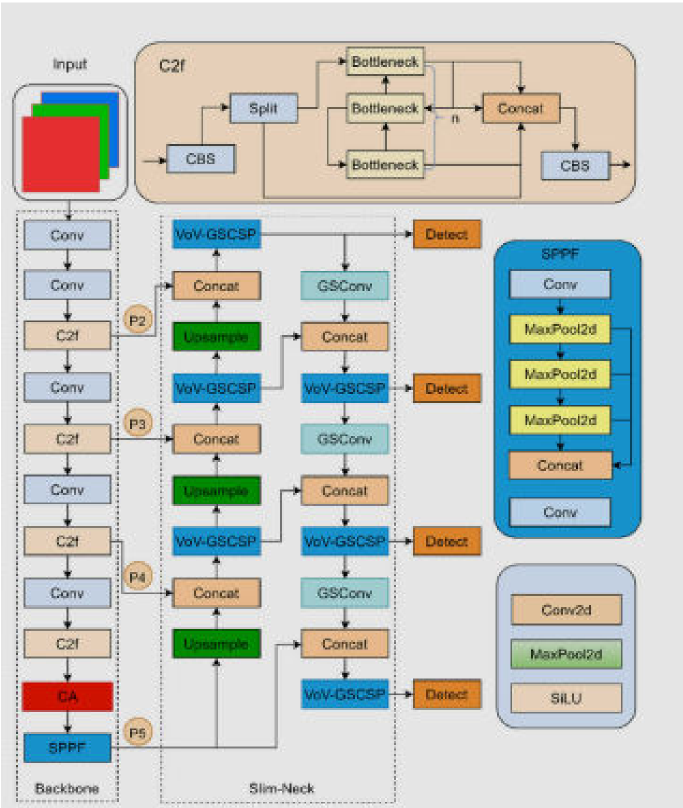

Figure 1: System Architecture

VI. IMPLEMENTATION

This project is implements like application using python and the Server process is maintained using the SOCKET & SERVERSOCKET and the Design part is played by Cascading Style Sheet.Interface the user interface is based on Struts provides HTML Tag. This project is implements like web application using Python and the Design part is played by Cascading Style Sheet.

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VII. EXPERIMENTAL RESULTS

Home page

Figure 1: Home Page

About Page

Figure 2: About Page

Uploading Image/video

Figure 3: Uploading Image/video

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Preview Page

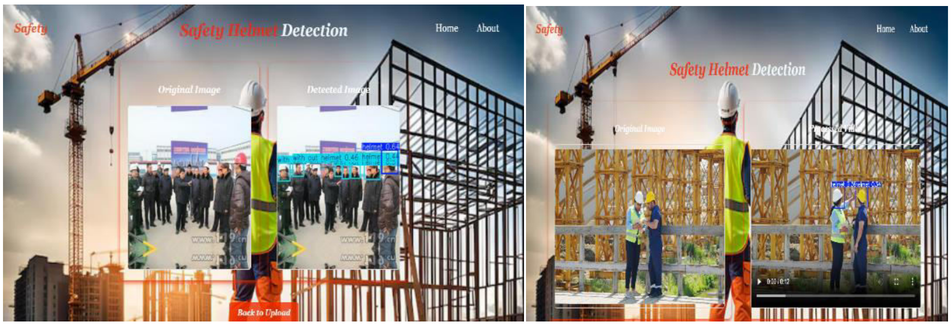

Figure 5 : Image/video Preview

VIII. CONCLUSION

Its positive impact on helmet wearing detection for enhanced workplace safety is evident. However, existing helmet detection models face challenges in recognizing small targets and complex backgrounds. This study proposes and implements an improved algorithm named YOLOv8n-SLIMCA to address these issues. Through a series of comparative and ablation experiments, the following conclusions are drawn: Adopting the Slim-Neck structure for feature fusion in the backbone network significantly reduces the model's size and computational load. Specifically, FLOPs decreased by 9.76%, parameters decreased by 6.98%, and speed improved by 9.52%, with minimal compromise on accuracy. Hence, the Slim-Neck structure proves to be an excellent lightweight module. Secondly, introducing Mosaic data augmentation, a small target detection layer, and the CA module effectively improves accuracy. Mosaic data augmentation enriches the dataset with small scale helmet samples; the small target detection layer aids the model in focusing on multiscale features, especially for small sized targets, thereby enhancing the accuracy of small target helmet detection. The CA attention module outperforms SE and CBAM attention mechanisms, allowing more focused attention on crucial regions and reducing interference from complex backgrounds. In summary, the proposed YOLOv8n-SLIM-CA algorithm, compared to the YOLOv8n algorithm, achieves a 2.151% improvement in mAP@0.5, reaching 94.361%. Its detection performance surpasses other algorithms in scenarios involving small targets, dense targets, and complex environments. This algorithm meets real-time and accuracy requirements for helmet detection and has low computational demands, with 11.3GB FLOPs, 2.74MB parameters, and 2.3 ms inference speed. It is suitable for deployment on mobile and edge devices, making it applicable for monitoring construction site videos and having broad applications in the industrial sector

IX. FUTURE ENHANCEMENT

The feature enhancements of YOLOv8 for safety helmet detection in this project include several key improvements. The Coordinate Attention (CA) mechanism helps the model focus on helmet regions, improving detection accuracy by reducing background noise. Additionally, the small target detection layer ensures that helmets, even when distant or partially obscured, are accurately detected. Mosaic data augmentation boosts the model's ability to handle complex scenes by creating synthetic training data, enhancing its performance in varied conditions. YOLOv8 also features a slim-neck structure that reduces model complexity while maintaining detection accuracy. It is optimized for computational efficiency, allowing for faster processing and making it suitable for deployment on devices with limited resources. These enhancements collectively improve the model's real-time processing capabilities and overall detection performance, making YOLOv8 highly effective for safety helmet detection in real-world, dynamic environments.

REFERENCES

[1] F. Zhou, H. Zhao, and Z. Nie, "Safety helmet detection based on YOLOv5," in Proc. IEEE Int. Conf. Power Electron., Comput. Appl. (ICPECA), Jan. 2021, pp. 6–11.
[2] L. Huang, Q. Fu, M. He, D. Jiang, and Z. Hao, "Detection algorithm of safety helmet wearing based on deep learning," Concurrency Comput., Pract. Exper., vol. 33, no. 13, p. e6234, Jul. 2021.

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[3] S. Sanjana, S. Sanjana, V. R. Shriya, G. Vaishnavi, and K. Ashwini, "A review on various methodologies used for vehicle classification, helmet detection and number plate recognition," Evol. Intell., vol. 14, no. 2, pp. 979–987, Jun. 2021.

[4] M. U. Farooq, M. A. Bhutto, and A. K. Kazi, "Real-time safety helmet detection using YOLOv5 at construction sites," Intell. Autom. Soft Comput., vol. 36, no. 1, pp. 911–927, 2023.

[5] K. Dahiya, D. Singh, and C. K. Mohan, "Automatic detection of bike-riders without helmet using surveillance videos in real-time," in Proc. Int. Joint Conf. Neural Netw., Jul. 2016, pp. 3046–3051.

[6] A. H. M. Rubaiyat, T. T. Toma, M. Kalantari-Khandani, S. A. Rahman, L. Chen, Y. Ye, and C. S. Pan, "Automatic detection of helmet uses for construction safety," in Proc. IEEE/WIC/ACM Int. Conf. Web Intell. Workshops (WIW), Oct. 2016, pp. 135–142.

[7] M.-W. Park, N. Elsafty, and Z. Zhu, "Hardhat-wearing detection for enhancing on-site safety of construction workers," J. Construct. Eng. Manage., vol. 141, no. 9, Sep. 2015, Art. no. 04015024.

[8] B. E. Mneymneh, M. Abbas, and H. Khoury, "Automated hardhat detection for construction safety applications," Proc. Eng., vol. 196, pp. 895–902, Jan. 2017.

[9] R. Girshick, J. Donahue, T. Darrell, and J. Malik, "Rich feature hierarchies for accurate object detection and semantic segmentation," in Proc. IEEE Conf. Comput. Vis. Pattern Recognit., Jun. 2014.

[10] R. Girshick, "Fast R-CNN," in Proc. IEEE Int. Conf. Comput. Vis. (ICCV), Dec. 2015, pp. 1440–1448.

[11] S. Ren, K. He, R. Girshick, and J. Sun, "Faster R-CNN: Towards real-time object detection with region proposal networks," in Proc. Adv. Neural Inf. Process. Syst., vol. 28, 2015.

[12] H. Liu, X. Wang, W. Zhang, Z. Zhang, and Y.-F. Li, "Infrared head pose estimation with multi-scales feature fusion on the IRHP database for human attention recognition," Neurocomputing, vol. 411, pp. 510–520, Oct. 2020.

[13] W. Yang, G. L. Zhou, Z. W. Gu, X. D. Jiang, and Z. M. Lu, "Safety helmet wearing detection based on an improved YOLOv3 scheme," Int. J. Innov. Comput., Inf. Control, vol. 18, no. 3, pp. 973–988, 2022.

[14] R. Cheng, X. He, Z. Zheng, and Z. Wang, "Multi-scale safety helmet detection based on SAS-YOLOv3-tiny," Appl. Sci., vol. 11, no. 8, p. 3652, Apr. 2021.

[15] J. Chen, S. Deng, P. Wang, X. Huang, and Y. Liu, "Lightweight helmet detection algorithm using an improved YOLOv4," Sensors, vol. 23, no. 3, p. 1256, Jan. 2023.

[16] Z. Li, W. Xie, L. Zhang, S. Lu, L. Xie, H. Su, W. Du, and W. Hou, "Toward efficient safety helmet detection based on YoloV5 with hierarchical positive sample selection and box density filtering," IEEE Trans. Instrum. Meas., vol. 71, pp. 1–14, 2022.

[17] L. Wang, X. Zhang, and H. Yang, "Safety helmet wearing detection model based on improved YOLO-M," IEEE Access, vol. 11, pp. 26247–26257, 2023.

[18] J. Bao, S. Li, G. Wang, J. Xiong, and S. Li, "Improved YOLOV8 network and application in safety helmet detection," J. Phys., Conf. Ser., vol. 2632, no. 1, Nov. 2023, Art. no. 012012. [19] F. M. Talaat and H. ZainEldin, "An improved fire detection approach based on YOLO-v8 for smart cities," Neural Comput. Appl., vol. 35, no. 28, pp. 20939–20954, 2023.

[20] Y. Li, Q. Fan, H. Huang, Z. Han, and Q. Gu, "A modified YOLOv8 detection network for UAV aerial image recognition," Drones, vol. 7, no. 5, p. 304, May 2023.

[21] D. Wu, S. Jiang, E. Zhao, Y. Liu, H. Zhu, W. Wang, and R. Wang, "Detection of camellia oleifera fruit in complex scenes by using YOLOv7 and data augmentation," Appl. Sci., vol. 12, no. 22, p. 11318, Nov. 2022.

[22] Z. Cao, M. Shao, L. Xu, S. Mu, and H. Qu, "MaskHunter: Real-time object detection of face masks during the COVID-19 pandemic," IET Image Process., vol. 14, no. 16, pp. 4359–4367, Dec. 2020.

[23] X. Jiang, T. Gao, Z. Zhu, and Y. Zhao, "Real-time face mask detection method based on YOLOv3," Electronics, vol. 10, no. 7, p. 837, Apr. 2021.

[24] G. Zhang, J. Yang, Y. Zheng, Y. Wang, Y. Wu, and S. Chen, "Hybridattention guided network with multiple resolution features for person reidentification," Inf. Sci., vol. 578, pp. 525–538, Nov. 2021.

[25] J. Hu, L. Shen, and G. Sun, "Squeeze-and-excitation networks," in Proc. IEEE/CVF Conf. Comput. Vis. Pattern Recognit., Jun. 2018, pp. 7132–7141.

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