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Performance Evaluation of YOLOv8 and YOLOv9 for Safety Helmet Detection in Construction Environments

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Abstract: *Ensuring worker safety through compliance with Personal Protective Equipment (PPE) mandates, particularly the use of safety helmets, is a critical concern in the construction industry. Automated surveillance systems leveraging advanced object detection models offer a promising solution to enhance monitoring and reduce accidents. This paper presents a comparative performance evaluation of two promi- nent YOLO (You Only Look Once) variants, YOLOv8 and YOLOv9, for the specific task of safety helmet detection. Utilizing a publicly available hard-hat dataset featuring diverse construction site scenarios, both models were trained for 7 epochs and rigorously evaluated. Performance metrics, including precision, recall, mean Average Precision (mAP), F1-score, and confusion matrices, were analyzed. The experimental results indicate that YOLOv9 exhibits a marginal but consistent performance advantage over YOLOv8, achieving an mAP@0.5 of 66.70% compared to YOLOv8's 65.73%, and an F1-score of 76.15% versus 75.66%. This study underscores the incremental improvements in the YOLO architecture and provides valuable insights for selecting robust models for real-world safety monitoring applications. While both models demonstrate high precision, the relatively lower recall suggests areas for future improvement through more extensive training or model fine-tuning to enhance detection rates in safety-critical environments.*

Keywords: Computer Vision, Construction Safety, Deep Learning, Object Detection, Performance Evaluation, PPE Monitoring, Safety Helmet Detection, YOLOv8, YOLOv9

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