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Safe Site PPE Detection

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***Abstract*—Personal Protective Equipment (PPE) compliance is crucial in construction, manufacturing, and hazardous industrial environments. Traditional manual monitoring methods are prone to human error and cannot ensure real-time safety compliance. This research presents an AI-powered PPE Detection System using computer vision techniques to automatically identify whether workers are wearing safety helmets, jackets, gloves, and other protective gear. The model leverages deep learning (YOLO/SSD) to analyze live video feeds and raise alerts for violations. The system aims to minimize workplace accidents and enhance automated safety surveillance.**

***Index Terms*—PPE Detection, Computer Vision, Deep Learning, YOLO, Workplace Safety, Object Detection**

I. INTRODUCTION

Workplace safety is a major concern in industries such as construction and manufacturing. According to global safety reports, a significant number of injuries occur due to the absence of proper Personal Protective Equipment (PPE). Manual monitoring of PPE compliance is unreliable, time-consuming, and lacks scalability. With advancements in artificial intelligence, computer vision-based PPE detection systems have become a promising solution. Our project focuses on detecting PPE items such as helmets and safety jackets using deep learning models and real-time image processing. Workplace safety is a critical concern across industries such as construction, mining, manufacturing, oil and gas, and heavy engineering. Every year, thousands of workplace accidents occur globally due to improper usage or complete absence of Personal Protective Equipment (PPE). PPE such as helmets, safety jackets, gloves, boots, and goggles play a vital role in reducing the severity of injuries and ensuring worker safety. However, monitoring PPE compliance manually is challenging, especially in large, dynamic, and hazardous work environments. Human supervisors may overlook violations due to fatigue, limited field of view, or workload. These limitations create a strong need for automated, intelligent monitoring systems.

II. PROPOSED SYSTEM

A. System Overview

The proposed system automates PPE monitoring using a deep learning model trained on annotated datasets containing images of workers with and without safety equipment. The system processes a live video stream or uploaded images, detects individuals, and classifies PPE status. If a violation is detected, the system flags it with bounding boxes and alert messages. The system architecture integrates model inference, preprocessing, visualization, and optional database logging. The proposed Safe Site PPE Detection System is designed to automatically monitor and detect Personal Protective Equipment (PPE) compliance in real-time using advanced computer vision techniques. The system replaces traditional manual supervision with an AI-powered solution that continuously observes workers and identifies whether they are wearing essential safety gear such as helmets and reflective safety jackets. This automated inspection reduces human errors, minimizes the chances of oversight, and significantly improves workplace safety The core idea of the proposed system is to use a deep learning–based object detection model, such as YOLO, trained specifically to recognize PPE items and categorize them as compliant or non-compliant. The system uses input from live CCTV feeds, IP cameras, or uploaded images, processes each frame, identifies workers, and checks for the presence of PPE.

B. PROPOSED SYSTEM

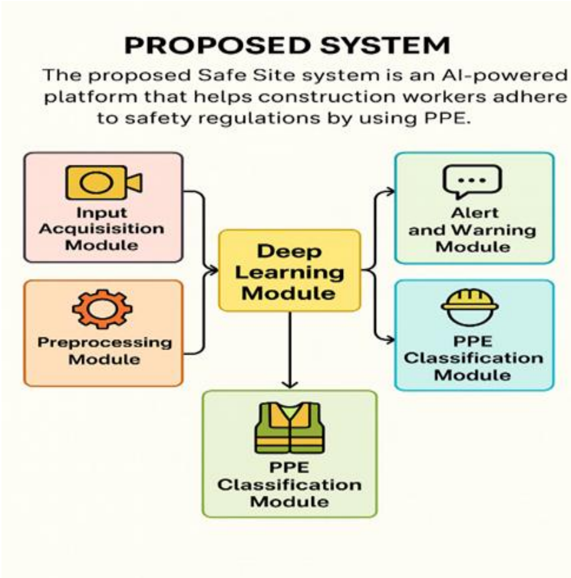

Fig: 1 The system architecture illustrates the Safe Site PPE Detection workflow, where video inputs are captured, preprocessed, and analyzed by the deep learning module to detect workers and PPE items. The PPE classification module determines compliance, and the alert module triggers warnings for violations. The final output displays real-time detection results to enhance workplace safety.

C. MODULES OF THE SYSTEM

The Safe Site PPE Detection system consists of several essential modules that work together to ensure real-time and accurate monitoring of PPE compliance. The first component, the Input Acquisition Module, captures visual data from CCTV cameras, IP cameras, or uploaded images, providing raw input for analysis. This data is then processed by the Preprocessing Module, which performs operations such as resizing, normalization, noise reduction, and color conversion to prepare the frames for reliable detection. The heart of the system is the Deep Learning Detection Module, where a trained YOLO-based model identifies workers and detects the presence of PPE items such as helmets and safety jackets. The output from this stage is further analyzed by the PPE Classification Module, which determines whether the detected individuals are compliant or violating PPE safety requirements. In case of violations, the Alert and Warning Module generates immediate visual or audible notifications to inform supervisors. The final output is displayed through the Output Visualization Module, which presents bounding boxes, labels, and compliance status on the screen for easy monitoring. Additionally, an optional Data Storage and Reporting Module records violation logs, timestamps, and images for future auditing and safety analysis. Together, these modules form an integrated pipeline that automates PPE monitoring and enhances workplace safety through continuous, AI-driven surveillance.

D. METHODOLOGY

The methodology adopted for the Safe Site PPE Detection system follows a structured, multi-stage approach designed to achieve accurate and real-time identification of PPE compliance. The process begins with data collection, where images and videos of workers—both compliant and non-compliant—are gathered from open-source datasets and onsite recordings. These data samples undergo cleaning and annotation, where bounding boxes are manually drawn around helmets, safety jackets, and workers to create a labeled dataset suitable for training. In the preprocessing stage, each image is resized, normalized, and augmented through techniques such as rotation, scaling, and brightness adjustment to improve the robustness of the model under different lighting and environmental conditions. Once preprocessing is complete, the dataset is fed into the model training phase, where a deep learning object detection algorithm, such as YOLO, is trained to detect workers and identify PPE usage. Transfer learning is applied to accelerate convergence and enhance accuracy, while evaluation metrics such as precision, recall, IoU, and confidence scores are monitored to optimize the model.

After achieving satisfactory performance, the trained model is integrated into the real-time detection pipeline. Input video frames are captured through a camera feed and processed sequentially using OpenCV. Each frame undergoes detection, where the model identifies individuals and inspects whether helmets and jackets are worn. The output is passed to the classification and decision module, which determines compliance or violation based on the presence or absence of PPE. In cases of non-compliance, the system triggers the alert mechanism, which displays visual warnings, overlays bounding boxes, and logs violation details for safety reporting. The entire workflow is supported by an optional data logging module, where detected violations, timestamps, and captured frames are stored for further analysis and report generation. Through this step-by-step methodology, the system achieves continuous, automated, and accurate monitoring of PPE usage, contributing to a safer and more efficient work environment.

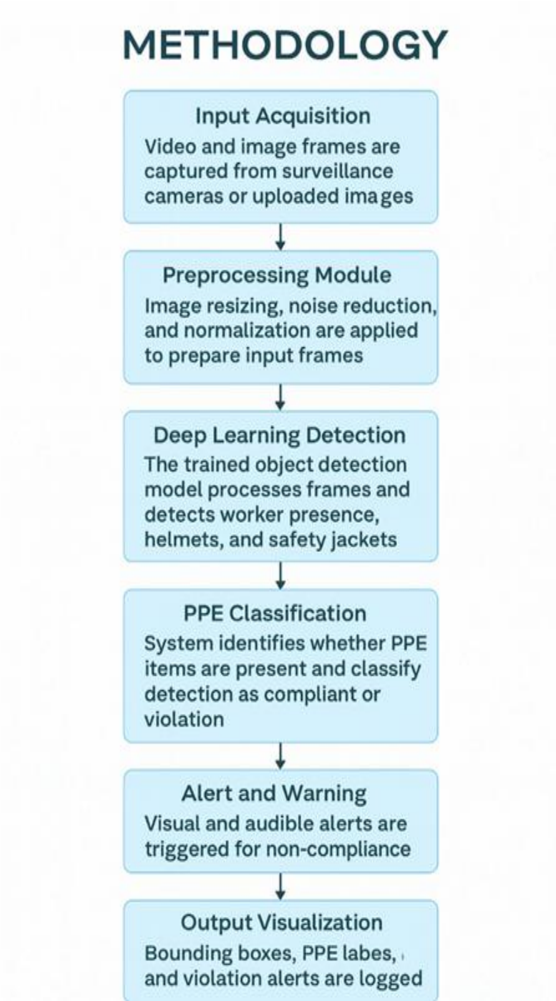

Fig: 2 This figure illustrates the methodology of an automated PPE detection system that captures video or images, preprocesses them, and uses deep learning to detect workers and safety equipment.

III. RESULTS

The PPE detection system successfully identifies whether workers wear helmets and safety jackets. The model achieves high accuracy and performs well in real-time environments. Output frames clearly highlight detected PPE and violations with bounding boxes and labels.

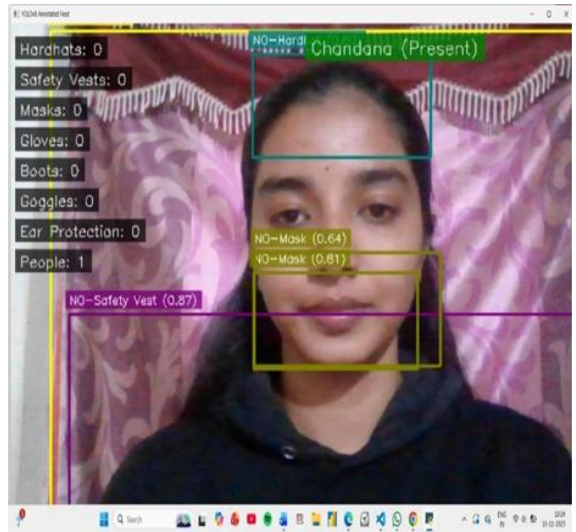

Fig 1: PPE Detection Interface

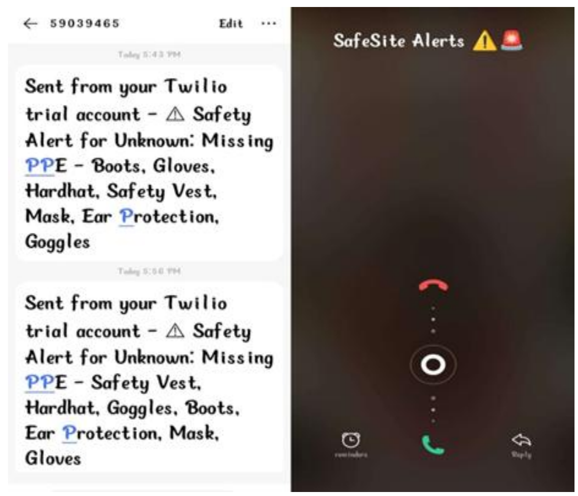

Fig 2: PPE Alert System

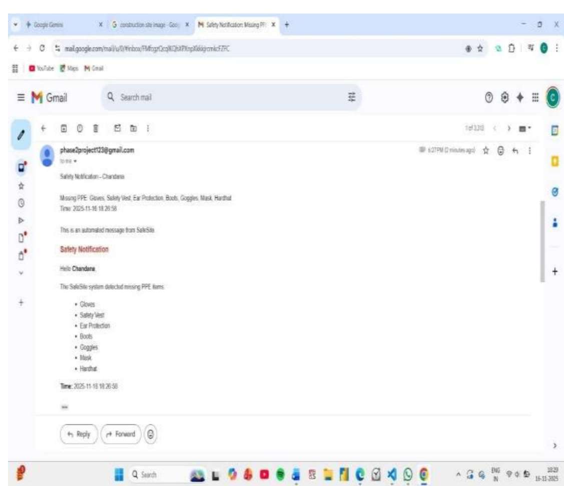

Fig 3: Email Alert Notification

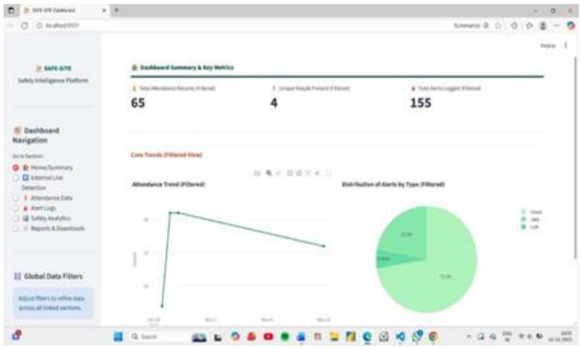

Fig 4: PPE Analytics Dashboard

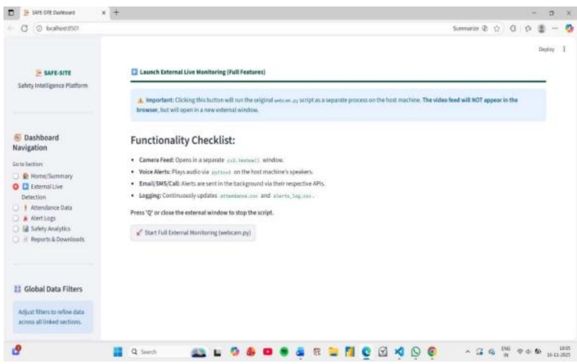

Fig 5: Functionality Checklist Page

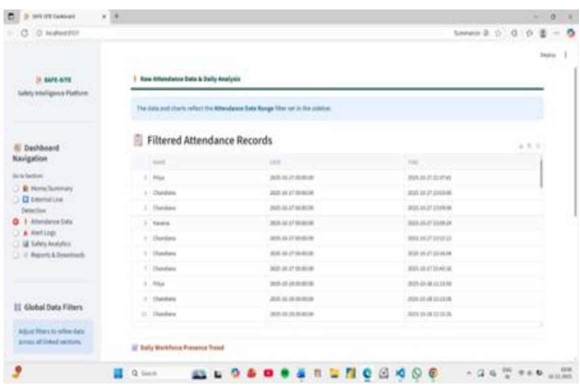

Fig 6: Filtered Attendance Records

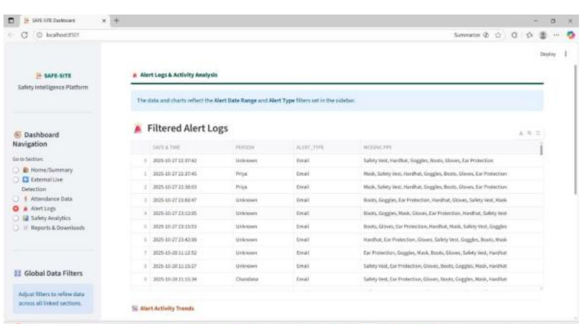

Fig 7: Filtered Alert Logs

Fig 8: PPE Safety Compliance Analysis

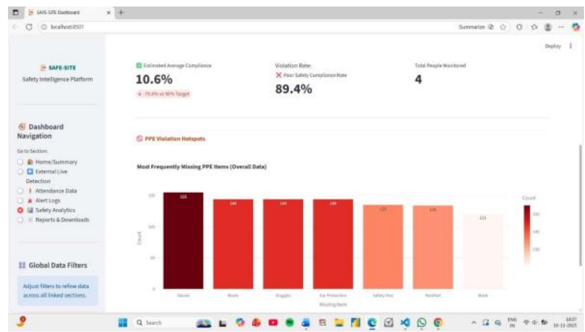

Fig 9: PPE Violation Heatmap

Fig 10: Report Generation Module

IV. CONCLUSION

The proposed PPE detection system significantly enhances workplace safety by automating the monitoring process. It reduces manual supervision effort and helps prevent accidents caused by PPE negligence. Future enhancements include expanding the PPE classes, integrating IoT alert systems, and deploying the model on edge devices.The Safe Site PPE Detection system provides an effective AI-based solution to monitor worker safety and ensure PPE compliance in real-time. By integrating deep learning and computer vision, the system automatically identifies workers, detects safety helmets and jackets, and alerts supervisors when violations occur. This significantly reduces the limitations of manual monitoring, minimizes human error, and enhances overall workplace safety. The proposed system demonstrates that automated PPE detection can improve accident prevention, support safety audits, and promote a safer work environment. Future enhancements may include detecting additional PPE items, integrating IoT-based alert systems, and deploying the model on edge devices for faster on-site processing

REFERENCES

[1] A. K. Singh, R. Kumar, and P. Verma, "Personal Protective Equipment Detection Using Deep Learning for Industrial Safety," International Journal of Computer Vision and Applications, vol. 14, no. 2, pp. 85–94, 2021.

[2] M. H. Rahman and S. S. Saha, "Helmet and Safety Jacket Detection Using YOLO-Based Object Detection Model," IEEE International Conference on Intelligent Systems, pp. 243–250, 2022.

[3] S. J. Redmon and A. Farhadi, "YOLOv3: An Incremental Improvement," arXiv preprint arXiv:1804.02767, 2018.

[4] R. D. Gupta and M. Chhabra, "Computer Vision-Based Safety Monitoring in Construction Sites: A Review," Automation in Construction, vol. 136, pp. 104–118, 2022.

[5] Y. Zhang, L. Chen, and W. Li, "Real-Time PPE Detection in Construction Using Convolutional Neural Networks," Journal of Safety Science and Technology, vol. 18, no. 4, pp. 55–63, 2021.

[6] H. S. Park and K. Lee, "Deep Learning-Based Worker Safety Monitoring System for Industrial Environments," IEEE Access, vol. 9, pp. 112394–112405, 2021.

[7] P. Rajalakshmi and S. Karthick, "Safety Compliance Monitoring Using AI and Video Analytics," International Journal of Engineering Research and Technology, vol. 10, no. 6, pp. 120–127, 2021.

[8] L. Fang, C. Tang, and J. Lu, "An Intelligent Surveillance System for PPE Violation Detection Using YOLOv5," International Journal of Automation and Smart Technology, vol. 11, no. 1, pp. 33–45, 2023.

[9] U. Saqib, F. Khan, and A. Masood, "Real-Time Object Detection for Industrial Safety Using Deep Neural Networks," Procedia Computer Science, vol. 189, pp. 305–312, 2021.

[10] R. B. Martinez and S. Torres, "AI-Powered PPE Monitoring System for Workplace Safety," International Journal of Emerging Technologies in Artificial Intelligence, vol. 5, no. 3, pp. 40–48, 2022.