REAL-TIME PPE COMPLIANCE DETECTION SYSTEM USING YOLOV8

Abstract

Safety is a major concern in construction and industrial sites. Many accidents happen simply because workers do not wear basic safety equipment such as helmets and safety vests. At present, safety officers have to monitor workers manually, which is difficult and not always effective, especially in large sites.

In this idea, we propose an AI-based vision system that can automatically check whether workers are wearing the required safety equipment using live video. The system uses a YOLOv8 object detection model to detect workers, helmets and safety vests from camera footage. The main aim of this proposed solution is to support safety teams, reduce manual monitoring effort and help create a safer working environment.

1. Introduction

Construction sites are busy and risky environments. Workers move continuously and often work near heavy machinery and at heights. Wearing proper Personal Protective Equipment (PPE) such as helmets and safety vests is one of the simplest and most important ways to reduce injuries.

However, in real situations, it is not easy to continuously check whether every worker is following safety rules. Supervisors cannot watch all camera feeds at the same time. Because of this, safety violations can easily be missed.

With recent developments in Artificial Intelligence and computer vision, it is now possible for computers to understand images and videos. Vision models can detect objects and people in real time. This proposed project uses such a vision model to automatically monitor PPE usage and help improve workplace safety.

2. Problem Statement

In most construction sites, PPE compliance is checked manually by supervisors. This approach is time-consuming, depends heavily on human attention and cannot scale well when many cameras and workers are involved.

There is a need for an automated system that can continuously monitor video feeds and automatically detect whether workers are wearing essential safety equipment such as helmets and safety vests.

3. Proposed Objectives

The main objectives of this proposed system are:

- To design an AI-based vision system for PPE monitoring
- To detect workers in live video streams
- To identify whether helmets and safety vests are worn

- To automatically indicate PPE violations
- To design a system that can be expanded for real-world deployment

4. Proposed System Overview

The proposed system will take video input from CCTV cameras or recorded videos. Each video frame will be processed using a YOLOv8 object detection model.

The model will detect three main objects in every frame:

- Person
- Helmet
- Safety vest

After detection, the system will check whether each detected worker is associated with a helmet and a safety vest. If both items are detected for a worker, the worker will be considered compliant. If one or both items are missing, the system will mark it as a PPE violation.

The final output will be shown as an annotated video with simple visual indicators.

5. Proposed Dataset Collection and Annotation

To build the proposed model, publicly available PPE image datasets will be used. These datasets contain images of workers wearing helmets and safety vests as well as images where PPE is missing.

Each image will be manually labelled using bounding boxes for:

- Workers (person)
- Helmets
- Safety vests

This labelled data will be used to train and validate the model.

6. Proposed Model and Technology

The proposed system will use the YOLOv8 object detection model because it is fast and well-suited for real-time video applications.

The main technologies planned for this project are:

- Python for implementation
- YOLOv8 using the Ultralytics framework
- OpenCV for handling video streams
- Annotation tools for labelling data

Using a pre-trained YOLO model will help reduce training time and improve performance.

7 . Algorithm

1. Capture live video stream from CCTV camera or load a recorded video file.
2. Extract video frames continuously from the input stream.
3. For each frame, apply the YOLOv8 object detection model.
4. Detect and classify the objects in the frame as Person, Helmet, and Safety Vest.
5. For every detected person, verify whether a corresponding helmet and safety vest are present inside the person's bounding box region.
6. If both helmet and safety vest are detected for a person, mark the worker as PPE Compliant.
7. If either the helmet or the safety vest is missing, mark the worker as a PPE Violation.
8. Display the processed frame with bounding boxes and compliance or violation labels.
9. Repeat the above steps continuously for all incoming frames to enable real-time monitoring.

8. Proposed Training Methodology

The collected and labelled dataset will be organised using a dataset configuration file. The YOLOv8 model will then be fine-tuned on this PPE dataset.

During training, the model will learn how helmets and safety vests look under different lighting conditions, camera angles and worker poses. The best performing model will be selected based on validation results.

9. Proposed PPE Compliance and Violation Logic

After detection, the system will analyse the location of helmets and safety vests with respect to each detected worker.

If a helmet and a safety vest are found inside a worker's bounding region, the worker will be marked as compliant. If either of them is missing, the system will highlight the worker as a PPE violation.

This simple logic allows the system to check compliance for each individual worker in the scene.

10. Expected Results and Evaluation

The proposed system is expected to detect workers, helmets and safety vests accurately in real time.

The performance of the model will be evaluated using commonly used object detection metrics such as precision, recall and mean average precision (mAP).

The output will clearly show bounding boxes and violation labels, making it easy for safety teams to understand the results.

11. Practicality and Actionability

One of the main strengths of this proposed system is its practicality. It can work with existing CCTV cameras and does not require specialised hardware for basic deployment.

Safety officers can use the system to automatically monitor multiple camera feeds and quickly identify unsafe situations. This helps reduce manual workload and allows faster response when safety rules are not followed.

12. Ethical and Privacy Considerations

This proposed system is intended only for safety monitoring. It does not aim to identify individual workers or perform face recognition.

All video data should be handled securely, and access should be limited to authorised personnel. Clear policies must be followed to ensure ethical and responsible use of surveillance data.

13. Expected Challenges

Some practical challenges are expected during future implementation, such as:

- Difficulty in detecting small helmets or vests in distant views
- Partial visibility of PPE items due to occlusion
- Poor lighting conditions
- Similar clothing colours affecting detection

These issues can be reduced by using a diverse training dataset and improving the detection model.

14. Future Scope

In the future, this proposed system can be extended to include:

- Detection of other PPE items such as gloves, masks and safety boots
- Automatic alert messages to safety supervisors
- A simple dashboard for monitoring and reporting
- Deployment on edge devices for faster and more efficient processing

15. Conclusion

This idea proposes a simple and practical AI-based solution for monitoring PPE compliance in construction and industrial environments. By using a YOLOv8 vision model, the system can automatically detect workers and check whether helmets and safety vests are worn.

The proposed approach has strong potential to improve safety monitoring, reduce manual effort and support better decision-making in real-world worksites. This idea submission forms a solid foundation for future development and deployment of an intelligent PPE monitoring system.