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Tech Titans: Real-Time PPE Detection and Alert System using camera

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Abstract
In settings such as industrial or construction worksites, ensuring workplace safety has been based on human inspectors doing rounds in the workplace or monitoring multiple video streams to continuously check for compliance with Personal Protective Equipment (PPE) wearing. Both approaches are tedious, manual, and can be prone to human errors. At the same time, new technology such as drones is too expensive or impractical for everyday safety monitoring.
In this paper, we describe Tech Titans, a low-cost real-time computer vision-based PPE detection and notification system implemented using Python, Django, OpenCV and the small, fast YOLOv8 Nano (YOLOv8n) model. It can be deployed as a ready plug-and-play system over existing infrastructure using CCTV, IP cameras, and other technologies. It can also monitor live feeds from cameras to check if employees are wearing hardhats, safety vests, masks and eye protection with defined ROIs (Regions of Interest) for specific monitoring. If a violation is detected, an annotated image of the violation with time stamp, location, and other details is sent back to the central dashboard with Email and MQTT notifications. As a message bus, you can use Tech Titans to publish direct hardware triggers to electronic devices on site such as sirens and warning lights in case of a potential safety incident. Tech Titans provides an easy and cost effective automated safety monitoring solution and auditing process for your facilities on-site.

Keywords: Personal Protective Equipment (PPE), Computer Vision, YOLOv8 Nano (YOLOv8n), Workplace Safety / Automated Safety Monitoring, Real-time Detection, Python / Django / OpenCV, Region of Interest (ROI), MQTT Notifications, Hardware Triggers, CCTV / IP Cameras.

1. Introduction

Workplaces that involve high-risk activities such as factory workshops, construction sites, and large-scale warehousing usually require extensive occupational health and safety (OHAS). One of the key aspects of OHAS is the mandatory use of personal protective equipment such as hardhats, high-visibility vests, masks, eye protection, among others. Interestingly, workers' compliance with PPE rules is considered one of the leading contributors to worksite incidents.
Typically, safety rounds and surveillance activities to detect PPE violations are conducted manually by appointed safety officers. However, such an approach can be very challenging and labor-intensive,

especially for large-scale worksites and multiple-facility networks. Recently, innovative approaches such as aerial visual surveillance using drones or robots have been proposed. Interestingly, such an option is either very expensive or has very limited applicability.

With these limitations in mind, it can be said that most PPE monitoring systems currently in use are reactive in nature – that is, they only detect and respond to incidents after the fact.

Computer vision algorithms are a promising alternative to the conventional approaches outlined above. However, there are three key challenges with regard to using existing computer vision models for industrial-grade PPE monitoring:

High Acquisition Costs

For most systems, the cost of acquisition and maintenance is unfeasible for most industrial or commercial facilities, especially those with extensive CCTV coverage or IP camera networks.

High Onsite Processing Requirements

Many computer vision applications require extensive processing power – typically in the form of GPU cards – which are both expensive and power hungry.

Lack of Immediate Response Mechanisms

Most computer vision applications are limited to making notifications or recording violations without any direct way of interacting with the physical environment.

Proposed System

This paper proposes Tech Titans – a computer vision application which aims to address the aforementioned limitations and provide a convenient, affordable solution for automated PPE monitoring and safety alerts. Using the fast inference speed of YOLOv8 Nano (YOLOv8n) and Django's robust web framework, Tech Titans implements a complete solution for automated safety auditing with notification and recordkeeping features.

Contributions of this work include:

- CCTV/RTSP Friendly: Can be used with existing CCTV or IP camera networks
- Per-Camera Customization: Ability to define customized Regions of Interest (ROIs) and PPE requirements per camera instance
- Immediate Hardware Triggers: Built-in support for MQTT message brokering for direct hardware interaction and immediate alerts
- Automated Recordkeeping: Built-in dashboard for managing audit trails and violation records with annotated photographs

This paper is structured as follows: Related Work is discussed in Section 2. Section 3 describes the system model used for this work. Implementation Details are detailed in Section 4. Finally, Section 5 provides concluding remarks and potential directions of future work.

2. Literature Review

1. Based on IJNRD2604694.pdf, Ramya et al. (2026)

Created a PPE detection system that uses computer vision and deep learning so that safety checks can happen in real time on factories and construction sites. The AI-based PPE detection system uses single-stage object detectors, YOLO and SSD that have been trained to spot many kinds of protective gear like helmets, masks, gloves, vests and safety shoes. The AI-based PPE detection system takes footage from security cameras. Runs image preprocessing and data augmentation, such, as resizing each picture to 640 by 640 pixels so it can keep working well no matter how light or dark the scene is. When the

AI-based PPE detection system sees a rule break it draws a bounding box around the item. Flashes a visual warning right away which cuts down on human mistakes and keeps the workplace under constant automated safety watch.

2. Based on the paper
A_Smart_System_for_Personal_Protective_Equipment_Detection_in_Industrial_Environments_Based_on_Deep_Learning_at_the_Edge.pdf, Gallo et al. (2022)

Introduced a real-time PPE detection system that runs on edge computing devices. The PPE detection system was built to work locally on low-cost hardware. The PPE detection system did not depend on cloud services. The PPE detection system used a Raspberry Pi 4 with an Intel Neural Compute Stick 2 (NCS2) and an Intel RealSense depth camera. The PPE detection system setup allowed Gallo et al. To check if workers were wearing equipment while keeping worker privacy and saving network bandwidth. The PPE detection system tested five neural networks that had been fine-tuned: YOLOv4, YOLOv4-Tiny SSD MobileNet V2, CenterNet ResNet50 V2 and EfficientDet D0. The PPE detection system evaluated these models across six categories: helmets, vests, gloves and the absence of each item. The PPE detection system results showed that YOLOv4 had the accuracy with an average precision of 95.3% at 50% IoU. However the PPE detection system selected YOLOv4-Tiny for real-time use on edge devices because it ran faster achieving 6.8 frames per second even though it was less accurate, than the models.

3. Based on
Automated_PPE_Compliance_Monitoring_using_Computer_Vision_and_YOLOv8.pdf

This study introduced an automated PPE compliance monitoring system that uses the YOLOv8 object detection model to check if workers are wearing safety gear in industrial areas. The system was trained on a dataset with labels for helmets, vests and safety footwear. It performs well in time running at more than 30 frames per second on regular GPU setups. The method includes preprocessing and data augmentation to deal with problems like occlusion and busy backgrounds. When the system detects that someone is missing a required piece of safety equipment it automatically logs the event. Sends an alert. This reduces the need, for human monitoring while still keeping a high mean Average Precision (mAP) in different types of industrial environments.

4. Based on
Real_Time_Workplace_Safety_Gear_Detection_via_Deep_Learning_Architectures.pdf

This research introduced a surveillance system that uses learning to check if people are wearing the right safety gear in real time. The method compares single-shot detectors (SSD). Custom Convolutional Neural Network (CNN) feature extractors to find people who are not following safety rules even when the lighting is bad or when parts of them are hidden. By processing the video stream and taking out space-related features the system can tell the difference between people who are following the rules and those who are not in situations, with people. The system works quickly so it can be used on the edge and gives alerts to safety managers helping to stop accidents before they happen in dangerous areas.

3. Problem Statement

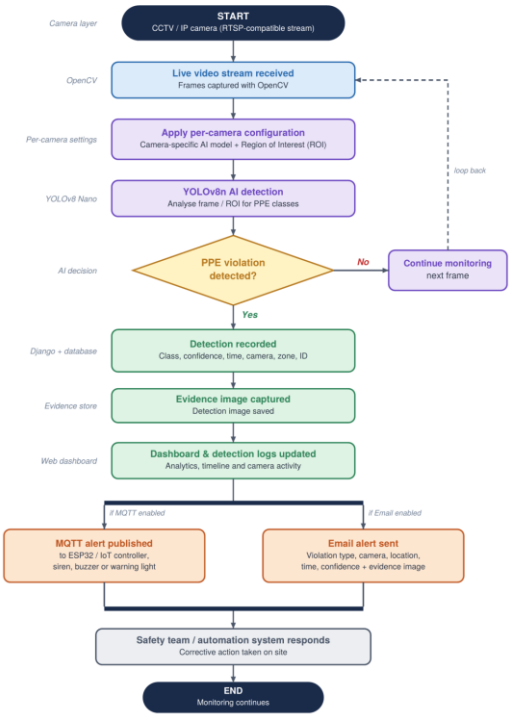
- **Workers may not always wear safety equipment.** In factories construction sites, warehouses and industries workers need to wear helmets, safety vests, masks and safety glasses to stay safe.
- **Checking workers manually is difficult.** Safety staff have to watch CCTV cameras continuously so it is difficult to notice every PPE violation.

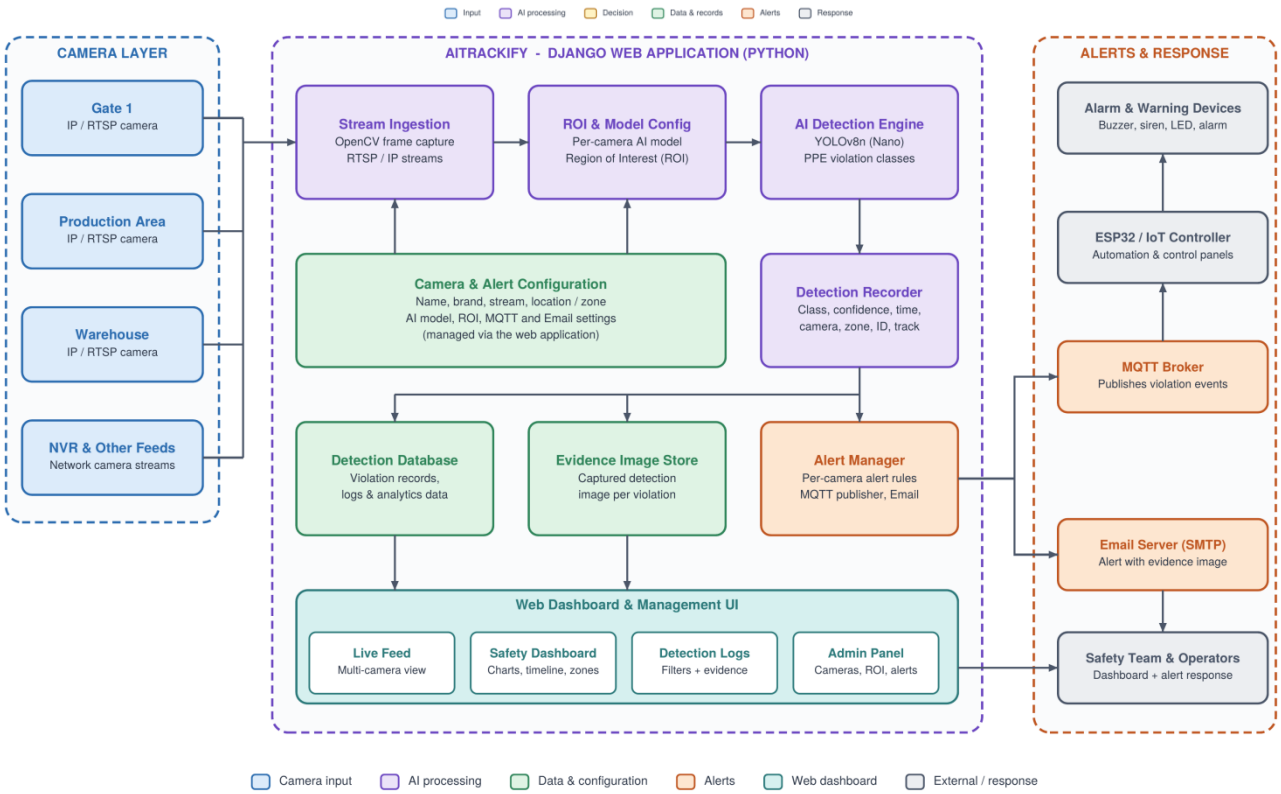
- **Normal CCTV only records the workplace.** It can. Save the video but it cannot automatically understand whether a worker is wearing the required safety equipment.
- **Safety violations can be. Noticed late.** If a worker is not wearing PPE the problem may not be noticed immediately which can increase the safety risk.
- **Keeping track of violations is also difficult.** It is important to know what happened where it happened, when it happened and have an image of the incident for checking.
- **Therefore a smarter monitoring system is needed.** The system should automatically check CCTV footage detect PPE violations save the incident and alert the team.
- **Tech Titans provides this solution.** It uses AI and YOLOv8n with existing CCTV/IP cameras to detect PPE violations in time save evidence show the information, on a dashboard and send email or MQTT alerts.

4. Proposed System

- Tech Titans will use existing CCTV/IP cameras to watch workers all the time.
- AI will look at the video from the cameras. Check if workers are wearing the needed personal protective equipment like helmets, safety vests, masks and safety glasses.
- If any personal protective equipment is not being used the system will find the mistake on its own of relying only on people watching manually.
- The system will keep a record of the mistake. Take a picture as proof of what happened.
- All the details will be shown on one dashboard, which makes it easier for safety workers to keep an eye on cameras and places.
- The system will also send warnings by email or MQTT so the right people can act fast.
- In total the system will make regular CCTV cameras smarter and better, for keeping workplaces safe.

5. Flow Chart and Block Diagram





6. Working

Tech Titans works by turning existing CCTV or IP cameras into an automated PPE safety monitor. Each camera is first registered in the Django web application, where the administrator enters its name, brand, stream URL (usually RTSP) and location or zone, and can also choose its AI model, an optional Region

of Interest (ROI), and its alert settings. Once a camera is enabled, OpenCV connects to its live stream and reads frames continuously. If an ROI has been defined, such as the worker entry area at Gate 6, only that part of the frame is analyzed, which keeps detection focused and reduces processing load. Each frame is then passed to the YOLOv8 Nano (YOLOv8n) model, a lightweight object-detection network built for fast, real-time inference, which identifies PPE-related classes such as No Hardhat, No Safety Vest, No Mask or No Safety Glasses and gives each a confidence score. When a detected class matches a violation enabled for that camera, the system records it in the database with the detection ID, class, confidence, date and time, camera, location and tracking information, and saves the annotated frame as evidence. The dashboard and detection logs are then updated, so operators can watch violations on the Live Feed, see analytics such as total violations, the most frequent alert type and the top alert zone, and search past records by time period. At the same time, the system sends alerts through the channels configured for that camera. MQTT alerts can trigger devices such as an ESP32 controlling a buzzer or warning light, and email alerts carry the violation type, camera, location, time, confidence and evidence image. In this way the safety team or an automation system can respond immediately, and the organization keeps an auditable record of every safety incident.

7. Result

The Tech Titans system was successfully implemented for real-time workplace safety monitoring using existing CCTV/IP camera infrastructure. The system uses YOLOv8n to identify PPE violations such as missing hardhats, safety vests, masks and safety glasses. Detected violations are recorded with confidence score, date and time, camera, location and evidence image.

During testing, the monitoring dashboard recorded 128 total safety violations. The most frequent alert type was No Glasses, with 41 detections, while Gate 6 was recorded as the top alert zone with 128 detections. The system also stored detection evidence and displayed the relevant information through the dashboard.

Result Workflow

CCTV / IP Camera Live video stream	→	**YOLOv8n** AI PPE detection	→	**PPE Violation** Detected	→	**Detection Record** Time • Confidence • Location	→	**Evidence Image** Detection captured	→	**Dashboard / Alert** Email / MQTT

Fig. 1. Tech Titans PPE detection and alert workflow

The workflow shows how the system processes a live CCTV/IP camera stream, performs YOLOv8n-based detection, records the violation and captures evidence, after which the dashboard is updated and configured alerts can be generated. This provides a continuous path from AI-based detection to safety-team response.

8. Conclusion

The Tech Titans system has been successfully designed and implemented to automate workplace PPE monitoring using artificial intelligence and computer vision. The integration of YOLOv8n, OpenCV and Django enables real-time analysis of CCTV/IP camera feeds and detection of configured safety violations.

The system provides a centralized dashboard for live monitoring, camera-specific configuration, detection history, evidence capture and safety analytics. It can also generate email and MQTT alerts when a configured violation is detected, helping the safety team respond to incidents more efficiently.
Overall, Tech Titans demonstrates how existing CCTV infrastructure can be enhanced with an AI-based safety layer. The system is applicable to construction sites, manufacturing plants, warehouses, factories and other safety-critical environments where continuous PPE compliance monitoring is required.

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