

AI-Powered PPE Compliance Monitoring

Using Surveillance Cameras & Deep Learning with a Focus on YOLO Architecture

This presentation outlines an advanced AI-driven system designed to monitor Personal Protective Equipment (PPE) compliance in real-time. Leveraging state-of-the-art deep learning models such as YOLO and pose estimation, the system aims to enhance workplace safety with instant alerts and accurate worker tracking.

By- Hitarth Mehra

Harshit Raj

Kiran Kumar S

Aniket

Aaditey Chalva





Project Objective

Real-Time PPE Detection

Automatically identify essential PPE items such as helmets, gloves, vests, and boots on workers via surveillance footage.

Human Pose Estimation

Assess human posture and positioning to verify correct usage of PPE and detect unsafe behaviors.

Alerts & Compliance Tracking

Generate immediate notifications for violations and maintain detailed compliance records for safety audits.

Methodology Overview

Data Collection & Annotation

Curated extensive video datasets capturing diverse PPE variations and annotated body keypoints for model accuracy.

Model Training & Detection

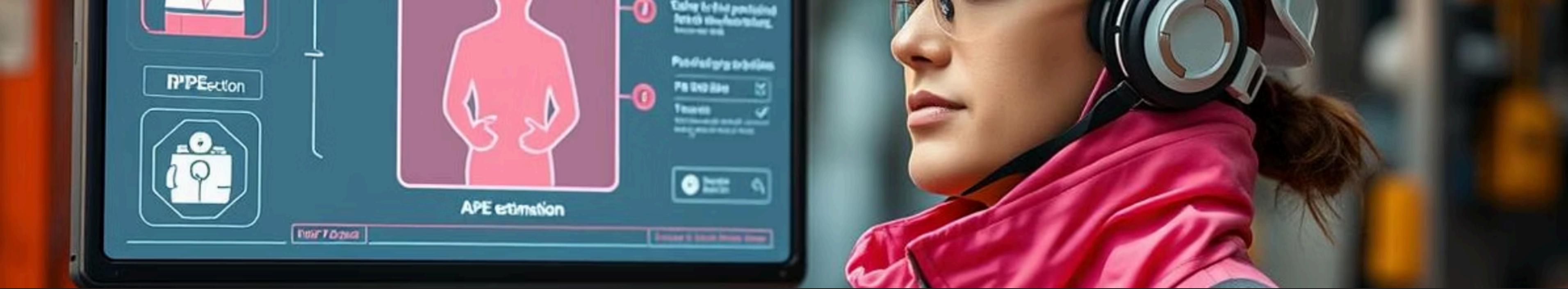
Utilized YOLOv8 and YOLO-Pose architectures for concurrent object detection and pose estimation on edge devices.

Classification & Tracking

Implemented posture classification (standing, sitting, lying) and worker tracking using DeepSort and OSNet ReID for persistent identity management.

Dashboard & Alerts

Developed a real-time dashboard to monitor compliance metrics and trigger alerts for non-compliance or emergencies.



Key System Features

Real-Time PPE Detection

Instant recognition of helmets, gloves, vests, and boots, ensuring on-the-spot compliance.

Advanced Pose Estimation

YOLO-Pose estimates body keypoints for accurate verification of PPE placement and worker posture.

Continuous Tracking

DeepSort combined with OSNet ensures persistent identification across complex scenes and occlusions.

Smart Notifications

Automated alerts for missing PPE or fallen workers, enhancing safety response times.

Innovative Aspects of Our Approach

PPE & Pose Cross-Verification

Combining object detection with pose estimation elevates compliance validation beyond simple presence checks.

Transfer Learning Adaptability

Quick retraining allows deployment across various industrial sectors without extensive new datasets.

Edge Deployment

On-device processing reduces bandwidth needs, ensures privacy, and lowers operational costs compared to cloud solutions.

Pose-Triggered Alerts

Alerts based on posture analysis enable rapid detection of accidents like falls or unsafe behavior.



Addressing Research Gaps

Low Light & Occlusion Solutions

Enhanced YOLOv8 models with data augmentation for reliable detection in challenging visibility conditions.

True PPE Usage Checks

Incorporating pose keypoints ensures PPE is worn correctly, not just detected visually.

Hardware Optimization

System engineered to operate efficiently on affordable Jetson Nano edge devices.

Privacy & Tracking Enhancements

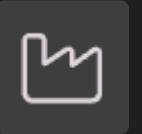
Face-blurring and local processing address privacy concerns while OSNet+DeepSort maintains worker identity tracking.

Commercial Advantages



Cost-Effective

Operates offline on small, affordable devices, reducing system deployment expenses.



Versatile Industry Use

Designed for mining, manufacturing, and construction environments with adaptable training modules.



Rapid Setup

Transfer learning and modular design enable fast integration into existing safety workflows.



Privacy-Compliant & Safe

On-device data processing and legal-safe approaches ensure regulatory compliance.



Real-Time Accident Prevention

Immediate smart alerts help mitigate workplace incidents and improve worker safety.

Technology Stack

Programming & Frameworks

- Python for rapid development
- PyTorch deep learning library
- YOLOv8 for object detection

Advanced Models

- YOLO-Pose for body keypoint estimation
- DeepSort and OSNet for robust tracking

Supporting Libraries

- OpenCV for image processing
- Scikit-learn for supplementary analytics
- Streamlit for real-time dashboard visualization

Edge Deployment

NVIDIA Jetson Nano enables on-site inference with low latency and energy efficiency.

Literature Insights & Foundations

Real-Time Accuracy

YOLO versions 7 to 11 have established the benchmark for fast and precise object detection critical for safety applications.

Pose-Based PPE Verification

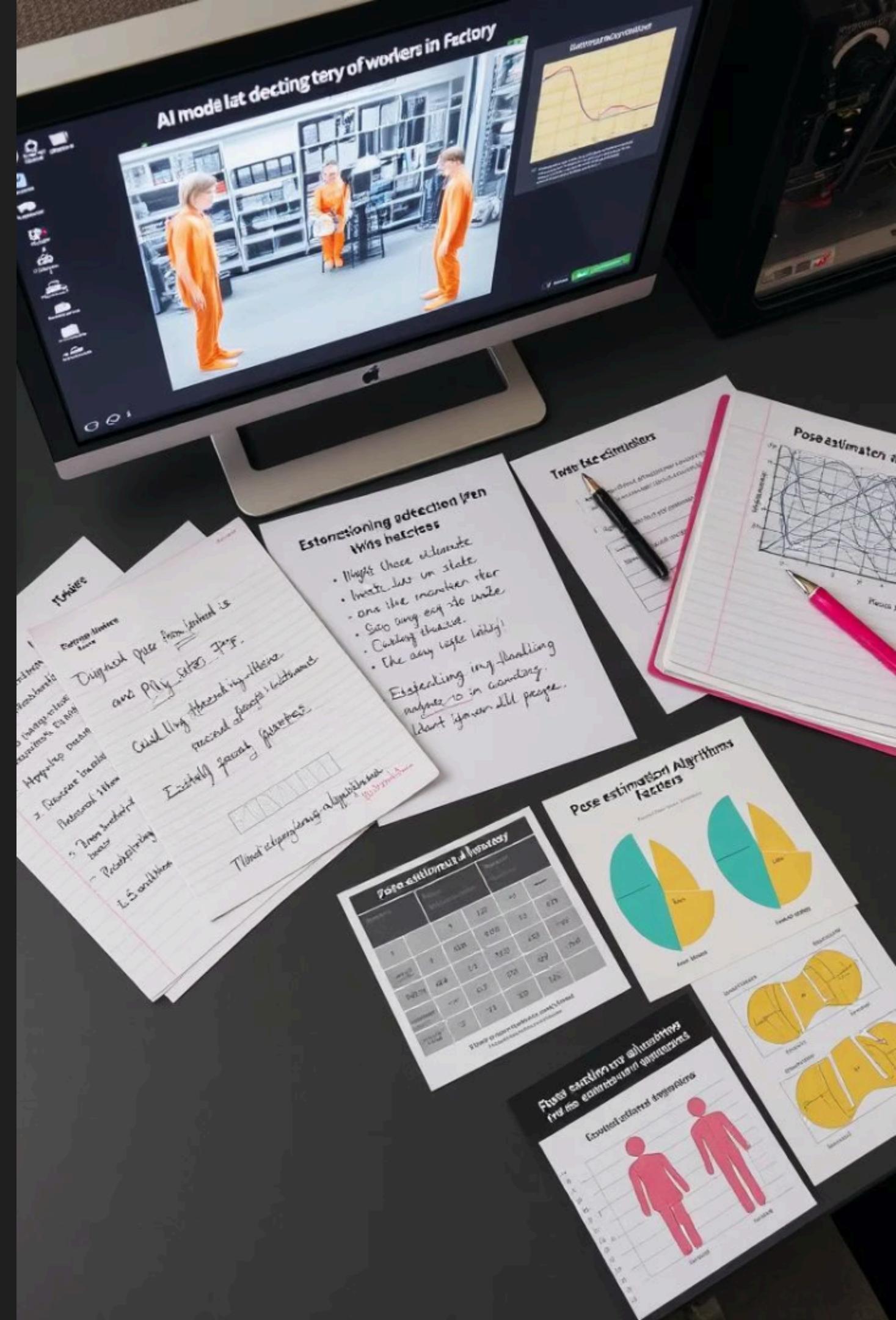
YOLO-Pose contributes reliably to PPE compliance by integrating body keypoint analysis.

Robust Multi-Person Tracking

DeepSort combined with OSNet excels in handling crowded work environments with complex occlusions.

Underground & Challenging Conditions

Research innovations emphasize adaptability for low-light and cluttered industrial sites.

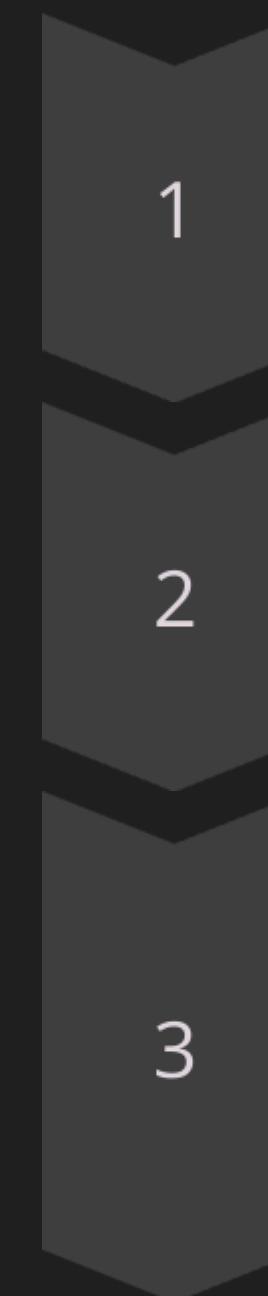


Literature Survey

<i>Paper</i>	<i>Contribution</i>
Wang et al. (2025)	YOLOv7 + ASFF for PPE in mines
Imam et al. (2025)	YOLOv8-YOLOv11 + pose estimation
Cai et al.	Early helmet detection using image features
Qi et al.	YOLOv5s with coordinate attention
Yipeng et al.	AL-YOLOv5 optimized for reflective gear



YOLO as the Core Technology



One-Pass Detection

Facilitates fast and accurate simultaneous object and pose detection in a single model pass.

Efficient Architecture

Anchor-free design and small model sizes ensure lightweight AI suitable for edge devices.

Advanced Components

- ASFF for detecting small gear like gloves and boots
- GhostNet enables efficient inference with reduced complexity
- YOLO-Pose provides precise PPE localization via body keypoints

Combining these innovations in the YOLO framework allows a comprehensive, real-time PPE compliance monitoring solution optimized for safety-critical industrial environments.