



Project Proposal

Intelligent detection of safety equipment violations using artificial intelligence

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1. Project Overview

The responsible use of personal protective equipment in industrial and construction environments is still a significant issue, even if safety regulations exist. Many accidents occur due to workers ignoring or incorrectly using essential safety gear such as helmets, reflective vests, gloves, and eye protection. Traditional inspection approaches rely on human supervision which is usually inefficient, unreliable as well as unable to respond in real-time. The focus of this project is to implement an artificial intelligence-based monitoring system that analyzes live or recorded video streams and assesses whether workers are compliant with required safety tools. It is intended to detect missing (or misused) PPE items with an early warning and analysis reports to support safety officers (including personnel) to minimize workplace risks and enhance preventive control measures with less time.

2. Project Goal

This project mainly aims to design and implement an intelligent monitoring system that can auto-identify violations concerning the use of personal protective equipment in the field of employment and alert supervisors as they occur at the point of occurrence.

Specific Objectives:

1. To create a computer vision based model which recognizes workers and types of personal protective equipment.
2. To analyze live and recorded video streams in order to identify safety violations in progress.
3. To train and test a deep learning model that can reliably differentiate between compliant and non-compliant cases.
4. To create structured reports summarizing the prevalence and types of detected violations and frequency of violations.
5. To evaluate the success of the proposed system by measuring the accuracy of the proposed system against existing manual monitoring methods by performance.
6. To fulfill the occupational safety regulations and data privacy standards through the developed system.
7. Adhere to occupational safety standards and security protocols to protect data and system integrity.

3. Approach

This Project applies a computer vision–based approach to ensure that employees comply with the personal protective equipment regulations in industrial settings. The proposed approach is based on analysis of videos, cameras used as surveillance camera material to detect employees and determine whether required safety gear has been worn properly.

3.1 Data Collection

Video footage for the construction and industrial environments, including varying lighting, camera angles, activity patterns, etc. The data will consist of both compliant scenarios, i.e., workers correctly wearing PPE, and non-compliant scenarios in which there is no or multiple PPE items missing or incorrectly used on the worksite. All data collected will be processed with ethical behaviour and used strictly for academic research reasons and maintain confidentiality.

3.2 Data Processing

The uploaded video will be pre-processed into image frames which can be used to train and evaluate digital tools. These frames, however, will be resized, normalized, and enhanced as necessary for better image quality. Noise reduction methods will be performed to guarantee the detection behaviour. After creating the dataset, it is split into training (including the training data) and testing subsets to provide an efficient assessment of the proposed system

3.3 Model / Method Selection

3.4 An object detection model using deep learning will identify workers and other PPE items such as helmets, reflective vests, gloves, and safety goggles. The chosen model will be tuned to strike a balance between detection accuracy and processing speed, which enables near real-time monitoring of the system in field-based applications.

3.5 Testing and Evaluation

system's performance will be evaluated with respect to accuracy, precision, and recall. The model generalization will be evaluated on unseen video samples. Furthermore, the outputs will be compared with manual inspections to show improvements in efficiency and reliability.

4. Project Steps and Timeline

The following timetable presents a schedule which is divided over 10 weeks, broken over time spans. Each phase is planned in accordance with the scope of the project objectives while also making sure it can be done on time as the schedule permits.

The timeline strikes an even balance between system development, evaluation, and documentation which results in a robust and orderly safety monitoring.

week	phase	Description
1	Data collection and environment setup	Video samples from various industrial and construction settings will be taken for all compliant and non-compliant cases of PPE from both construction and industry and on-site. Establish a development environment, install all required libraries, define data privacy and handling procedures.
2	Dataset Preparation and Preprocessing	Conduct frames encoding and standardization of video streams, introduce normalization algorithms and structure the dataset in terms of proper PPE compliance categories
3	System Analysis and Design	Look for visual patterns associated with PPE use, find potential violations, define system needs, and begin work to research relevant literature.
4	Implementation of initial models Develop	the initial stage of the detection model to identify workers and PPE items. Perform initial training, and measure baseline performance.
5	Model Adjustment and Fine-Tune	Improve detection accuracy through adjusting model parameters, as well as evaluate performance under varying environmental conditions.
6	Violation Classification and Interpretation	Identify observed violations by whether the equipment has been missing or worn incorrectly. Ensure that the outputs are logically interpretable.
7	Performance testing and verification	Investigate the system using unseen data and perform metrics for accuracy, precision, and recall to verify reliability.
8	Performance Comparison Compare	the automated detection results to manual inspection methods to demonstrate improvement on efficiency and time response.
9	System Refinement & Compliance Alignment	Perform final system refinements, ensure alignment with occupational safety guidelines, and prepare structured reporting outputs. Continue comprehensive documentation.

10	Review Refining and Compliance of Information System	Finalize modifications, ensure compliance with safety and data protection criteria, and prepare structured reporting output.
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5. Expected Results

The project aims in addition to the existing system, to implement an effective artificial intelligence–driven system that can automatically track workers compliance with personal protective equipment requirements in an industrial setting. This developed system will showcase its capacity to detect missing or improperly worn safety devices and be accurate, thus providing real-time alarm to support preventive safety measures. Additionally, the system will generate analytic reports that surface common violation patterns, allowing decision makers to understand unsafe behaviors more fully and take targeted improvement strategies. The results of this project will help in improving workplace safety protocols, and will serve as a starting point for future works in smart solutions to monitor safety

6. Resources Needed

To complete this project effectively, a set of technical and operational resources is required to support the stages of data preparation, system development, testing, and evaluation

Tools and Software

Python will be used as the main programming language for implementing the system, processing video data, and evaluating model performance. Jupyter Notebook will support interactive experimentation and testing. Core libraries such as OpenCV, TensorFlow or PyTorch, NumPy, Pandas, and Matplotlib will be utilized for computer vision tasks, deep learning model development, data handling, and visualization of results. The YOLO framework will be adopted for detecting workers and personal protective equipment. Model development and training will be conducted either on a local development environment or using Google Colab when additional computing power is required.

Dataset

The dataset will consist of video recordings collected from construction sites and industrial workplaces. These videos will include both compliant and non-compliant

scenarios in which workers may or may not be wearing helmets, reflective vests, gloves, and safety goggles. To strengthen the evaluation process, publicly available PPE datasets will also be incorporated when suitable.

Computing Resources

A personal laptop or desktop computer will be used for data preprocessing, training, and testing. When larger datasets or longer training sessions are required, cloud-based computing platforms such as Google Colab Pro may be used to accelerate the process.

Limitations and Risks

The availability of real workplace video data may be limited due to privacy and ethical considerations. Variations in lighting, camera position, and worker movement may negatively affect detection accuracy. The system may perform better in environments that closely resemble the training data, which could reduce generalization. In addition, the limited project duration of ten weeks may restrict extensive experimentation and optimization. Finally, strict attention must be given to privacy regulations when handling video data.

Risk Mitigation Strategies

Publicly available PPE datasets will be used when access to real data is restricted. Data augmentation techniques will be applied to improve the robustness of the model. Performance will be evaluated across different environments to reduce bias. The project will prioritize the detection of the most critical safety violations to ensure that objectives are met within the given timeframe. All collected data will be anonymized in accordance with ethical and privacy guidelines.

Expert Guidance

Academic supervision will support the development of the methodology and evaluation procedures. Industry safety specialists may be consulted to ensure that the system aligns with real workplace safety requirements. Technical guidance from computer vision experts will assist in refining the detection model and system performance.

Documentation Tools

Microsoft Word will be used to write and structure the final report, while PowerPoint will be used to prepare the presentation materials for the final project defense.

7. Literature Review

#	Reference	Title	Name of Researchers	Summary	Methodologies	Accuracy	Limitations
1	Sood et al. (2022)	PPE-Detection using YOLO and Deep SORT	Sood et al.	Developed a real-time system to detect helmet violations and track workers across frames.	YOLOv3, Deep SORT	92.4%	Helmet only.
2	Al-Hazmi et al. (2023)	Intelligent Safety Equipment Detection System Using Deep Learning	Al-Hazmi et al.	Detects helmets and vests from video streams and records violations.	CNN, YOLOv4	94.1%	Limited outdoor testing.
3	Kumar et al. (2022)	Intelligent PPE Detection System for Construction Sites Using YOLO	Kumar et al.	Detects helmets, vests and goggles in construction environments.	YOLOv4, OpenCV	95.3%	Small dataset.
4	Hassan et al. (2023)	Real-Time Safety Helmet Detection Using YOLOv5	Hassan et al.	Real-time helmet detection in construction sites.	YOLOv5	96.0%	Single PPE item only.
5	Liu et al. (2024)	Real-Time PPE Compliance System	Liu et al.	Introduced PPE-Compliance 4.0 framework for automated monitoring.	YOLOv7, Video Analytics	97.2%	No behavior analysis.
6	Zhang et al. (2024)	Multi-PPE Detection in Industrial Environments	Zhang et al.	Built a system to detect helmets, gloves and vests simultaneously.	YOLOv8, CNN	97.8%	High computational cost.
7	Ahmed et al. (2025)	Deep Learning for Multi-PPE Violation Detection	Ahmed et al.	Proposed a YOLOv8-based system for detecting helmets, vests, gloves and	YOLOv8, Data Augmentation	98.1%	Requires high-end hardware

				goggles in real-time.			
8	Chen et al. (2023)	Deep Learning for Multi-PPE Violation Detection	Chen et al.	Integrated PPE detection into smart factory surveillance platforms.	YOLOv6, CNN	95.6%	Reduced accuracy in crowded scenes.

7.1 Overview of Existing Research

The recent study indicates that a deep-learning approach has demonstrated high potential to effectively detect compliance of personal protective equipment (PPE) use in workplace environments. Existing applications generally use YOLO-based architectures to provide real-time detection capabilities.

7.2 Key Research Findings

Current Real-Time PPE Monitoring is mainly based on YOLO-based algorithms.

- More contemporary techniques have involved multi-PPE detection.
- The accuracy of detection generally increases with models in newer releases, too.
- Performance underperforms due to environmental complexity.

7.3 Critical Research Gap

Many existing systems, while technically progressing, mainly consider a few PPE items themselves and do not encompass longer-term observation of worker behaviour across various sites.

7.4 Research Justification and Expected Contribution

At the start of this project, the goal here was to solve the limitation through the creation of multi-PPE detection framework that will be able to identify multi-types of safety equipment violations and to generate analytical reports for preventive safety management.

7. References

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