

Hazard Detect AI: An Intelligent PPE Compliance Detection System Using YOLOv8

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Abstract - Workplace safety is an essential requirement in industrial and construction sectors, where failure to follow safety regulations can result in accidents and injuries. Ensuring that workers wear appropriate Personal Protective Equipment (PPE), particularly safety vests, is important for maintaining a safe working environment. However, manual monitoring of safety compliance can be time-consuming and may not always be effective in large workplaces.

This study presents **Hazard Detect AI**, an intelligent safety monitoring system developed using the YOLOv8 object detection model. The proposed system analyzes workplace images to identify whether workers are wearing safety vests and automatically detects safety violations. A labeled dataset containing images of compliant and non-compliant workers is used for training and evaluating the model. To improve accessibility and usability, the trained model is integrated into a web-based application that enables users to upload images and obtain instant detection results.

The system provides visual identification of detected objects along with confidence scores, supporting accurate assessment of workplace safety compliance. Experimental evaluation demonstrates that the proposed approach delivers reliable detection performance and can effectively assist in automated safety monitoring. The developed solution reduces the need for continuous manual supervision, improves compliance tracking, and contributes to safer industrial and construction environments through intelligent workplace monitoring.

Key Words: Workplace Safety, Hazard Detection, YOLOv8, Deep Learning, Computer Vision, PPE Compliance, Safety Vest Detection.

1. INTRODUCTION

Workplace safety is a fundamental requirement in industries such as construction, manufacturing, mining, and infrastructure development, where workers are frequently exposed to hazardous conditions. Maintaining a safe working environment

is essential for preventing accidents, protecting human lives, and ensuring uninterrupted industrial operations. Failure to comply with safety regulations can result in serious injuries, equipment damage, financial losses, and reduced productivity. Among the various Personal Protective Equipment (PPE) used in workplaces, safety vests play a crucial role in enhancing worker visibility and minimizing the risk of accidents, especially in areas with heavy machinery and moving vehicles.

Traditional methods of monitoring safety compliance primarily rely on supervisors and manual inspections. While these approaches are widely used, they often face challenges in large-scale and dynamic work environments. Continuous observation of every worker is difficult, and human supervision may be affected by factors such as fatigue, distraction, and limited coverage. As a result, safety violations can go unnoticed, increasing the likelihood of workplace incidents. These limitations create a need for intelligent and automated solutions capable of monitoring safety compliance more efficiently and consistently.

Recent advancements in Artificial Intelligence (AI), Deep Learning, and Computer Vision have transformed the way visual data is analyzed and interpreted. Modern object detection models can accurately identify and classify objects within images and videos, enabling automated monitoring in various domains. Among these models, YOLOv8 has gained significant attention due to its high detection accuracy, fast processing speed, and suitability for real-time applications. These capabilities make it an effective tool for workplace safety monitoring and PPE compliance detection.

This study presents **Hazard Detect AI**, an intelligent safety monitoring system developed using the YOLOv8 object detection framework. The proposed system automatically analyzes workplace images to determine whether workers are wearing safety vests and provides instant detection results through a web-based application. By integrating deep learning techniques with an accessible user interface, the system supports automated safety compliance monitoring, reduces dependence on manual inspections, and promotes safer working conditions. The proposed solution demonstrates the potential of artificial intelligence in enhancing workplace

safety and contributing to the development of smart industrial environments.

2. PROBLEM STATEMENT

Workplace safety is a critical concern across industries such as construction, manufacturing, mining, and infrastructure development, where employees are regularly exposed to potentially dangerous working conditions. In these environments, strict adherence to safety regulations is essential to minimize accidents, injuries, and operational disruptions. Among the various safety measures implemented in industrial settings, the use of Personal Protective Equipment (PPE) plays a vital role in protecting workers from hazards. Safety vests, in particular, are widely used to improve worker visibility and reduce the risk of accidents involving machinery, vehicles, and other workplace activities. Despite the existence of established safety guidelines, ensuring that every worker consistently follows PPE requirements remains a significant challenge.

Traditional methods of monitoring safety compliance mainly depend on manual inspections and direct supervision by safety officers or site managers. Although these approaches are commonly practiced, they have several limitations. Large construction sites and industrial facilities often contain hundreds of workers operating simultaneously across different locations, making continuous monitoring difficult. Human supervision can be affected by fatigue, distraction, limited visibility, and oversight, which may result in unnoticed safety violations. As a consequence, workers who fail to wear safety vests may remain undetected, increasing the possibility of accidents, injuries, and non-compliance with workplace safety regulations. In addition to safety concerns, such incidents can lead to productivity losses, legal liabilities, and increased operational costs for organizations.

The rapid advancement of Artificial Intelligence (AI), Deep Learning, and Computer Vision technologies has created new opportunities for addressing these challenges through automated monitoring solutions. Modern object detection algorithms are capable of analyzing images and identifying objects with high accuracy and speed. These capabilities make them suitable for workplace safety applications where real-time detection and continuous monitoring are required. By utilizing intelligent detection systems, organizations can reduce dependence on manual inspections while improving the consistency and effectiveness of safety compliance monitoring.

Despite the availability of advanced technologies, many workplaces still lack efficient automated systems for detecting safety vest compliance. Existing monitoring approaches are often unable to provide continuous surveillance and immediate identification of violations. This limitation highlights the need for a reliable and scalable solution capable of automatically recognizing whether workers are wearing safety vests in workplace environments. Such a system should be able to analyze visual data, identify non-compliance accurately, and provide timely feedback to support corrective actions.

Therefore, there is a need to develop an AI-driven workplace safety monitoring framework that can automatically detect safety vest usage using computer vision techniques. By integrating deep learning models with automated image analysis, the proposed solution can improve monitoring efficiency, reduce human effort, and enhance workplace safety management. The implementation of such a system can support compliance with safety regulations, minimize accident risks, and contribute to creating safer, smarter, and more productive industrial environments.

3. OBJECTIVES

The primary objective of this study is to develop an intelligent workplace safety monitoring system that can automatically detect safety vest compliance using artificial intelligence and computer vision techniques. Workplace environments often require continuous supervision to ensure that workers follow safety regulations. However, manual monitoring can be time-consuming, labor-intensive, and prone to human error. Therefore, the proposed system aims to provide an automated solution that improves the efficiency and reliability of safety compliance monitoring.

The study focuses on utilizing the YOLOv8 object detection model to analyze workplace images and identify whether workers are wearing safety vests. By processing visual information automatically, the system can accurately recognize safety compliance and detect violations without the need for constant human observation. This capability helps organizations improve workplace safety standards and reduce the risk of accidents caused by non-compliance with safety requirements.

Another important objective is to integrate the trained detection model into a web-based application that offers a simple and user-friendly interface. Through this platform, users can upload workplace images and obtain instant detection results. The system is designed to provide quick feedback, making it suitable for practical use in industrial and construction environments where timely safety assessments are essential.

The research also aims to evaluate the performance of the proposed model using standard assessment metrics and visualization techniques. Performance analysis helps determine the accuracy, reliability, and effectiveness of the detection framework under different operating conditions. This evaluation ensures that the system can consistently deliver dependable results in real-world scenarios.

Overall, the study seeks to demonstrate the potential of artificial intelligence in enhancing workplace safety management. By automating safety vest detection, improving compliance monitoring, and reducing the possibility of overlooked violations, the proposed system contributes to creating safer working environments and supports the adoption of intelligent safety solutions in modern industries.

4. METHODOLOGY

The methodology adopted in this study follows a systematic approach for developing an intelligent safety vest detection system using artificial intelligence and computer vision techniques. The process begins with the collection of workplace images containing workers wearing safety vests as well as workers without safety vests. These images are carefully annotated and organized into a structured dataset suitable for training an object detection model. To improve the quality and diversity of the dataset, preprocessing techniques such as image resizing, normalization, and augmentation are applied. These steps help enhance the robustness of the model and improve its ability to perform accurately under different workplace conditions.

After preparing the dataset, the YOLOv8 object detection model is selected and trained to recognize safety vest compliance from workplace images. During the training phase, the model learns important visual features and patterns associated with safety vest usage. The training process is monitored continuously to optimize performance and reduce prediction errors. Once training is completed, the model is evaluated using standard performance metrics such as precision, recall, accuracy, and F1-score to assess its effectiveness and reliability. Various graphical analyses are also performed to gain insights into the model's learning behavior and detection performance.

Following successful evaluation, the trained YOLOv8 model is integrated into a Flask-based web application to enable practical deployment. The application provides a user-friendly interface through which users can upload workplace images for analysis. When an image is submitted, the system processes the input, performs safety vest detection, and generates prediction results along with visual indicators. The detected objects are highlighted, and relevant information is presented to the user in real time. This integrated approach combines dataset preparation, deep learning model development, performance evaluation, and web deployment to create an efficient and reliable workplace safety monitoring solution.

The overall methodology ensures accurate detection of safety vest compliance while reducing dependence on manual supervision. By leveraging advanced object detection techniques and web technologies, the proposed system supports automated workplace safety management and contributes to the prevention of safety violations in industrial and construction environments.

The application of artificial intelligence in workplace safety monitoring has gained significant attention due to its ability to automate compliance checking and reduce workplace hazards. Traditional safety inspection methods rely heavily on manual supervision, which can be time-consuming, labor-intensive, and prone to human error. To address these limitations, researchers have explored the use of computer vision and deep learning techniques for detecting Personal Protective Equipment (PPE) and monitoring worker safety in industrial and construction environments. These technologies enable automated analysis of visual data and provide faster, more consistent, and reliable safety assessments.

Several studies have utilized object detection models such as YOLO, Faster R-CNN, SSD, and Convolutional Neural Networks (CNNs) to identify safety equipment including helmets, safety vests, gloves, goggles, and protective footwear. Among these approaches, YOLO-based models have become particularly popular because of their high detection accuracy and real-time processing capability. Researchers have demonstrated that deep learning models can effectively recognize safety-related objects from images and video streams, making them suitable for continuous workplace monitoring. The use of image augmentation, transfer learning, and large annotated datasets has further improved the performance and robustness of these systems.

Recent advancements in deep learning have contributed to significant improvements in detection speed, accuracy, and scalability. Modern object detection frameworks are capable of processing complex workplace scenes while maintaining reliable performance under varying lighting conditions and environmental challenges. Many studies have reported successful deployment of AI-driven safety monitoring systems that can identify safety violations in real time and provide immediate feedback for corrective action. These developments highlight the growing potential of intelligent monitoring solutions in enhancing workplace safety, supporting regulatory compliance, reducing accident risks, and promoting safer industrial operations through automated surveillance and timely intervention.

6. SYSTEM DESIGN

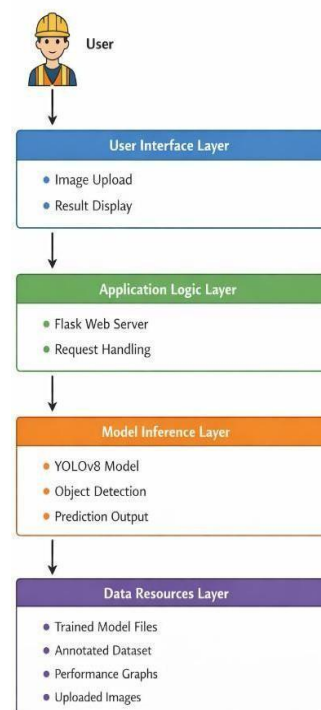


Figure 1: System Architecture

The Hazard Detect AI system is developed to provide an automated solution for monitoring safety vest compliance in workplace environments. The system utilizes a web-based platform through which users can upload workplace images for analysis. Once an image is submitted, it is processed by a trained YOLOv8 object detection model that identifies workers and determines whether they are wearing the required safety vests. This automated process helps in detecting safety violations quickly and accurately without requiring continuous human supervision.

The framework combines image processing, object detection, and result presentation within a unified architecture. The uploaded images are analyzed by the detection model, and the generated results are displayed through an intuitive interface. Users can view detection outcomes, confidence scores, and safety-related information, allowing them to assess compliance levels efficiently. The integration of these components ensures smooth data flow from image input to result generation, making the system practical for workplace safety applications.

The architecture also includes support modules responsible for managing datasets, trained model files, uploaded images, and performance evaluation outputs. These resources enable efficient system operation and facilitate future model improvements. By combining deep learning technology with a user-friendly web interface, the proposed framework delivers reliable safety vest detection and supports effective workplace safety management.

The overall system design emphasizes accuracy, scalability, and ease of use. Its modular structure allows future enhancements such as real-time video monitoring, multi-PPE detection, and cloud-based deployment. As a result, the Hazard Detect AI system serves as a robust platform for automated safety compliance monitoring and contributes to creating safer industrial and construction work environments.

7. SCREENSHOTS

1. Home Page

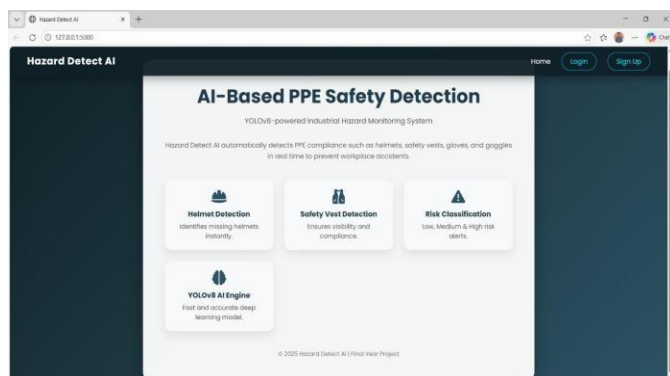


Figure 2 : Home Page

2. User Sign-Up Page

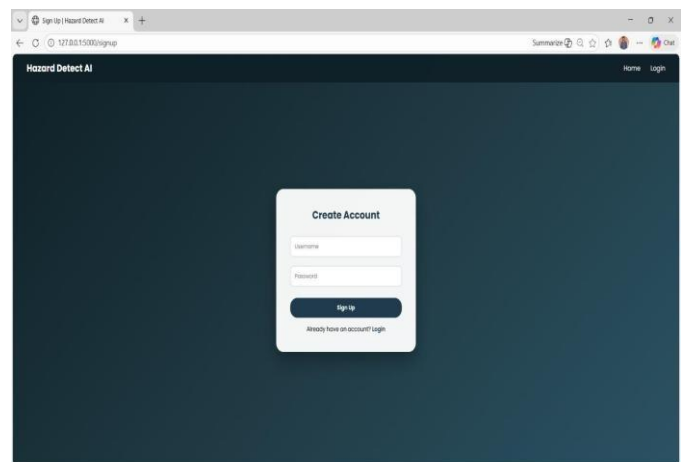


Figure 3: User Sign-Up Page

3. Login page

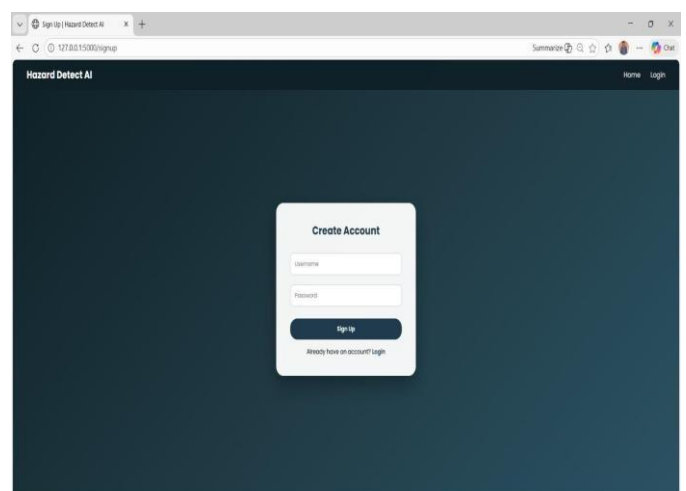


Figure 4: Login Page

4. Upload Page

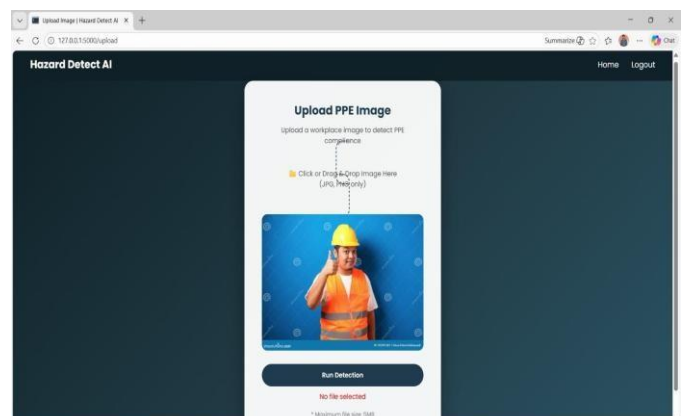


Figure 5: Upload Page

5. Prediction Result Page

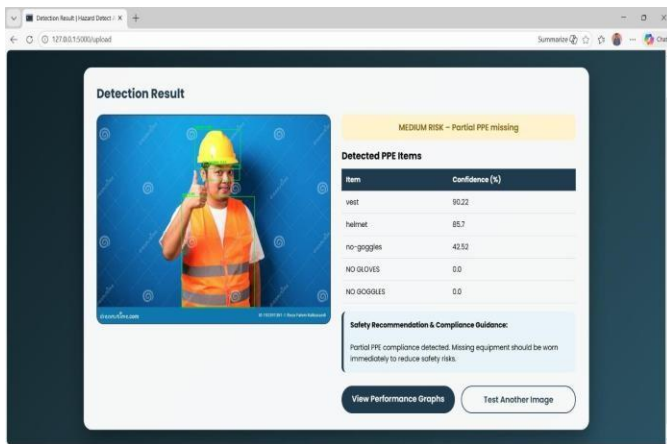


Figure 6: Prediction Result Page

6. Model accuracy pages

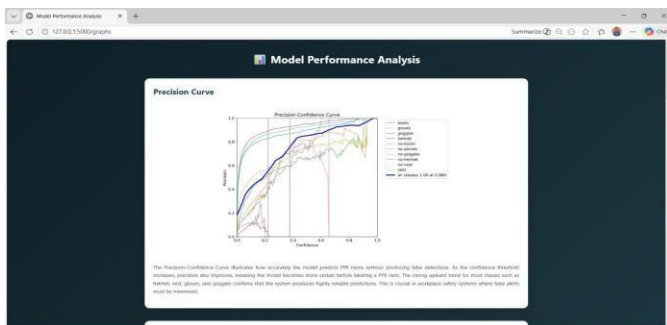


Figure 7: Model accuracy page

7. Confusion Matrix Page



Figure 8 : Confusion Matrix Page

8. CONCLUSION & FUTURE SCOPE

The Hazard Detect AI system demonstrates the practical application of artificial intelligence and computer vision in enhancing workplace safety. By employing the YOLOv8 object detection model, the system can automatically identify safety vest compliance from workplace images and provide accurate detection results. The integration of the detection model with a web-based application enables users to perform safety inspections quickly and efficiently. This approach minimizes the dependence on manual supervision and supports continuous monitoring in industrial and construction environments.

The proposed framework contributes to improving workplace safety by enabling timely identification of safety violations and promoting compliance with safety regulations. Its ability to process visual data automatically helps reduce human error and increases the effectiveness of safety management practices. The experimental results indicate that deep learning-based detection systems can serve as reliable tools for automated workplace monitoring and hazard prevention.

Future developments may focus on expanding the system's capabilities to support real-time video surveillance and continuous monitoring through CCTV cameras. The framework can also be enhanced to detect multiple types of Personal Protective Equipment (PPE), including helmets, gloves, safety shoes, and protective goggles. Such extensions would allow the system to provide a more comprehensive safety compliance solution.

Additional improvements may include the integration of alert and notification mechanisms, cloud-based deployment, and mobile application support for remote access. Continuous dataset expansion and model optimization can further improve detection accuracy and robustness. These enhancements will increase the scalability, accessibility, and practical usability of the system, making it suitable for a wider range of workplace safety applications.

9. REFERENCES

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