Industry Safety Detection using Computer Vision

MASTER OF SCIENCE IN ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

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Industry Safety Detection using Computer Vision

Capstone project submitted as part of the fulfillment of the course curriculum for the third semester of the

Master of Science

in

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by

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under the guidance of

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Declaration by Candidate

I hereby declare that the project titled "**Industry Safety Detection using Computer Vision**" is the result of my own work, conducted with dedication and under the valuable guidance of Dr.Soumendu Chakraborty at the Indian Institute of Information Technology, Lucknow. This project has not been submitted, either wholly or in part, for any other degree or academic credit at this or any other institution. All sources of information used have been acknowledged.

Saurabh Kumar Singh
Roll No: MSA23011

Certificate by Supervisor

This is to certify that the capstone project titled "**Industry Safety Detection using Computer Vision**" submitted by **Saurabh Kumar Singh** (Roll No.: MSA23011) has been carried out under my guidance and supervision. This project has been conducted as part of the fulfillment of the course curriculum for the third semester of the Master of Science degree in Artificial Intelligence and Machine Learning. The work presented in this report is, to the best of my knowledge, a result of the student's independent efforts and it meets the academic standards required for this degree program. I hereby endorse the project and recommend it for evaluation.

Dr.Soumendu Chakraborty

(Department of Computer Science)

Indian Institute of Information Technology, Lucknow

Date: Signature:

Acknowledgment

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Contents

1 Abstract

This project presents an innovative approach to workplace safety through the development of an industry safety detection (ISD) system. The system employs computer vision and machine learning technologies to automatically detect and verify the proper usage of Personal Protective Equipment (PPE) among industrial workers. By monitoring seven critical safety components **dust masks, eyewear, gloves, jackets, protective boots, protective helmets, and shields** the system aims to prevent workplace accidents and ensure compliance with safety regulations. The implementation of real-time monitoring and automated alert systems represents a significant advancement in industrial safety management.

2 Introduction

2.1 Background

Workplace safety remains a critical concern across industrial sectors globally. Despite technological advancements and stringent regulations, industrial accidents continue to occur, often due to non-compliance with safety protocols, particularly regarding the proper use of Personal Protective Equipment (PPE). Traditional methods of safety compliance monitoring, which typically rely on human supervision, are prone to inconsistencies and limitations in coverage. The Industry-Safety-Detection (ISD) system represents a technological solution to this challenge, leveraging the power of computer vision and machine learning to create an automated, reliable, and continuous monitoring system for PPE compliance.

2.2 Problem Statement

In recent decades, there's been a lot of neglect in terms of safety and well-being in most industries. The practice of safety culture and safety climate is growing every day to safeguard all workers/employees in the work environment. Government bodies and other regulatory organizations have implemented rules and laws which ensure that employers/companies create working conditions that nullify, or at the very least minimize the probabilities of accidents, injuries, etc. in the workplace. Ignorance, incompetence, lack of knowledge/training, and overconfidence among other human errors also play a part in the occurrence of such negative incidents

- Ignorance about safety protocols
- Lack of proper knowledge and training
- Incompetence in executing safety measures
- Overconfidence that leads to risk-taking behavio

2.3 Project Scope

Scope of the Application This scope of the project focuses on identifying the equipment of industrial workers by detecting all the safety gears such as masks, eyewear, gloves, jackets, protective boots, protective helmets, and shields By that, the system can determine if the employee/worker is having proper safety to do their work or not. The data of detections are also uploaded into the local database.

Object Presentation

Object Detection

Assign Identities

3 Literature Review

The field of safety helmet detection has witnessed significant advancements through various deep learning approaches, particularly using YOLO (You Only Look Once) variants. These techniques aim to enhance safety monitoring in construction and industrial environments.

3.1 YOLO-Helmet Algorithm

[3]The YOLO-Helmet algorithm addresses critical challenges in safety helmet detection, making it a promising solution for real-time monitoring in construction sites [?]. The study emphasizes the importance of advanced deep learning techniques in improving safety management and reducing workplace accidents. Future research directions include further model optimization to minimize missed detections.

3.2 YOLOv8n-ASF-DH Model

[2]The YOLOv8n-ASF-DH model provides a robust solution for automatic safety helmet detection, significantly enhancing safety monitoring in construction and industrial environments [?]. The project underscores the significance of integrating advanced deep learning techniques to address real-world safety challenges. Potential future work involves optimizing inference speed and exploring applications in other object detection domains.

3.3 YOLO v5-based Method

[1]The study presents a YOLO v5-based method that effectively enhances safety helmet detection capabilities, promoting worker safety in construction environments. Proposed future work includes further model optimization and expanding the application to broader safety monitoring tasks.

3.4 YOLOv8n-SLIM-CA Algorithm

[2]The YOLOv8n-SLIM-CA algorithm effectively enhances safety helmet detection, demonstrating suitability for real-time monitoring systems on construction sites [?]. Its lightweight design and improved accuracy position it as a valuable tool for workplace safety enhancement.

3.5 YOLO-M Approach

[4]YOLO-M addresses helmet detection challenges in complex construction environments, offering a balanced approach to accuracy and efficiency [?]. Future research aims to enhance the model's robustness across diverse scenarios.

4 Methodology

4.1 DATASET COLLECTION

The dataset used in the experiment is from the Roboflow dataset and the class of the dataset (eyewear, Dustmask, Gloves, jacket, Protective Boots, Protective Helmets, Shields) is publically available on the internet, which contains 2311 images and has been labeled with **seven** categories safety and not safety. Since the annotation format was Yolo v11 format and randomly divided into 2311 training set, 462 validation set, 231 test set

4.2 System Architecture

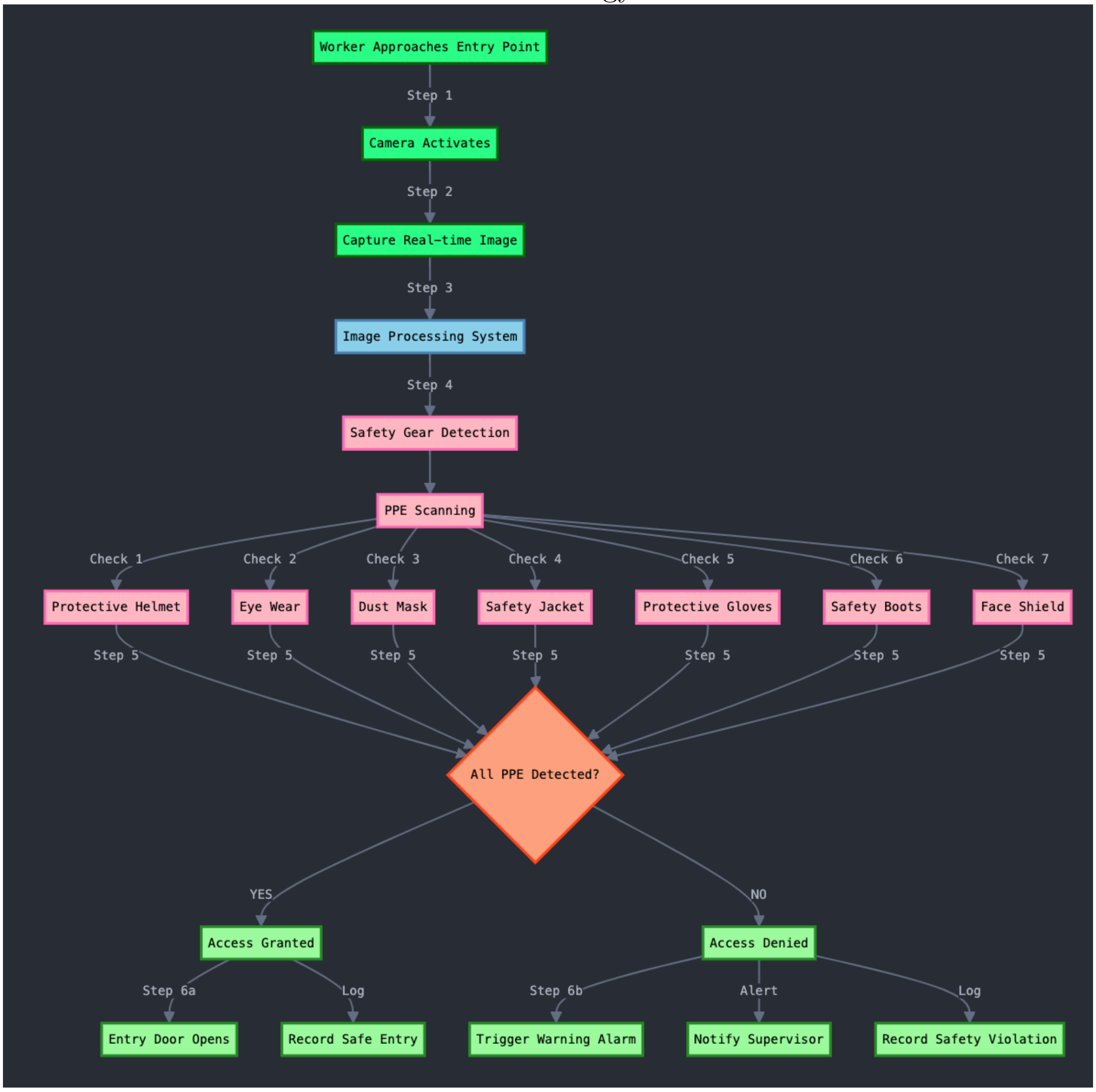
The ISD system employs a layered architecture:

Algorithm 1 PPE Detection Algorithm

```
procedure DetectPPE(image)
    preprocessed_image ← Preprocess(image)
    detections ← ObjectDetector.detect(preprocessed_image)
    ppe_components ← ClassifyPPE(detections)
    compliance_status ← VerifyCompliance(ppe_components)
    return compliance_status, ppe_components
end procedure
```

4.3 Flowchart

The flowchart below visually represents the step-by-step process of the methodology



4.4 Input Layer

- High-resolution cameras
- Image capture systems
- Video streaming capabilities
- Input validation

4.5 Processing Layer

- Image preprocessing
- Feature extraction
- Object detection
- Classification algorithms

4.6 PPE Detection Algorithm

```python
# Pseudocode for PPE detection
def detect_ppe(image):
    # Preprocess image
    processed_image = preprocess(image)

    # Apply object detection
    detections = object_detector.detect(processed_image)

    # Classify PPE components
    ppe_components = classify_ppe(detections)

    # Verify compliance
    compliance_status = verify_compliance(ppe_components)

    return compliance_status, ppe_components
```

5 Implementation Strategy

5.1 Phase 1: System Setup

- Hardware installation
- Software deployment
- Network configuration
- Initial testing

5.2 Phase 2: Algorithm Development

- Model training
- Algorithm optimization
- Performance testing
- Validation procedures

6 Expected Outcomes

6.1 Safety Improvements

- Reduced accident rates
- Increased compliance
- Better safety awareness
- Proactive risk management

6.2 Result

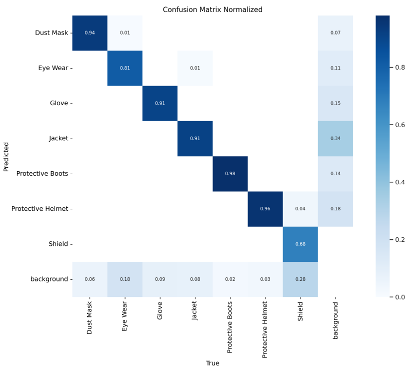


Figure 1: confusion matrix

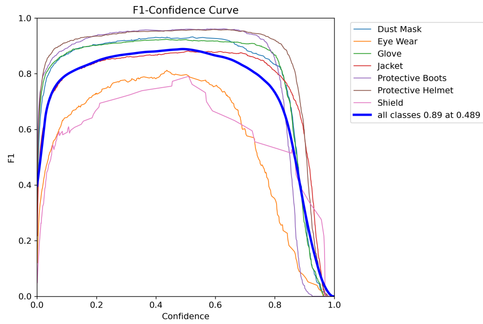


Figure 2: F1 curve

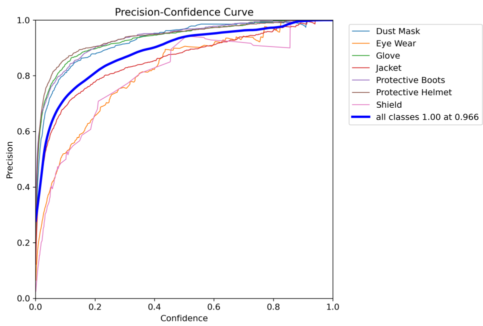


Figure 3: P curve

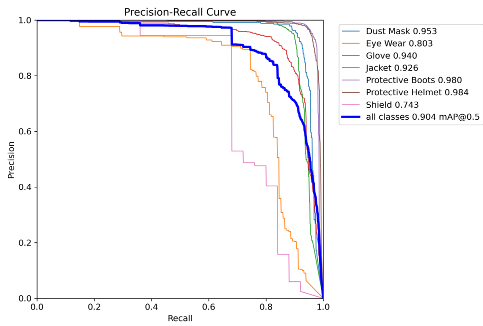


Figure 4: PR curve

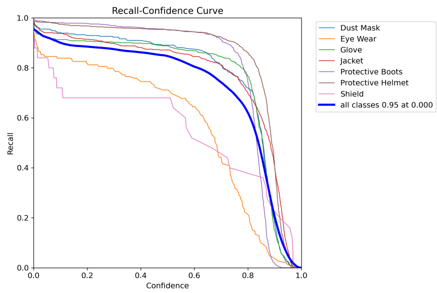


Figure 5: R curve

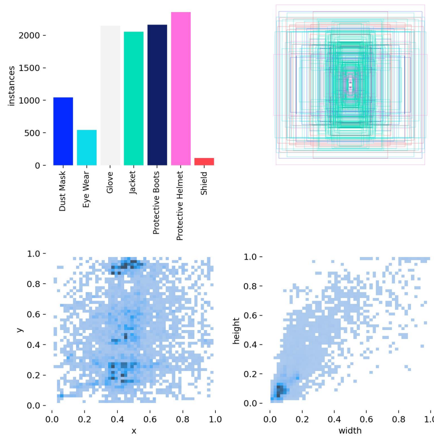


Figure 6: labels

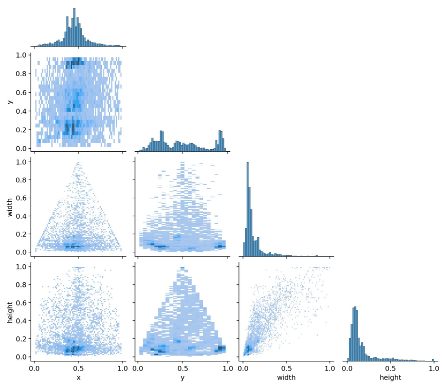


Figure 7: labels correlogram

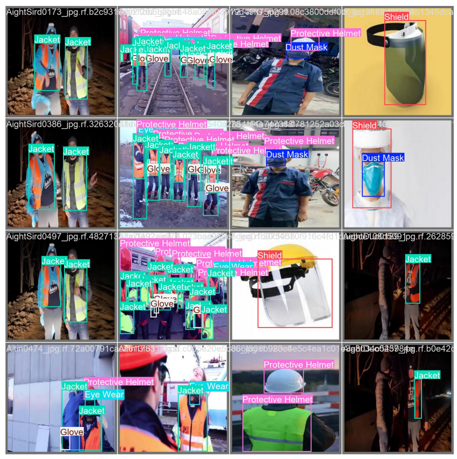


Figure 8: Result image

7 Conclusion

The Industry-Safety-Detection system represents a significant advancement in workplace safety monitoring. By leveraging computer vision and machine learning technologies the system provides automated, reliable, and continuous monitoring of PPE compliance.The implementation of this system is expected to contribute significantly to workplace safety improvement and accident prevention in industrial settings.

References

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