Problem Statement Background

In industrial facilities and laboratory environments, enforcing safety compliance such as wearing protective helmets/caps, safety shoes, and protective eyewear (goggles/specs) is critical to prevent accidents, injuries, and operational hazards.

Despite the importance of these safety measures, compliance monitoring is still largely manual or dependent on periodic inspections. These approaches are:

- Labour-intensive
- Inconsistent across shifts and locations
- Difficult to scale in high-traffic environments
- Prone to human error

Conventional CCTV systems lack intelligence and cannot automatically detect whether safety rules are being followed. Many existing AI solutions operate on static images, lack real-time capabilities, or fail to associate violations with specific individuals for tracking and auditing.

There is a strong need for an AI-driven computer vision system that can automatically monitor safety compliance in industrial and laboratory contexts, associate violations with individuals, and provide actionable insights through a web-based interface.

Problem Statement Objective

Design and develop an end-to-end AI-powered system that detects safety compliance in industrial or laboratory environments using computer vision and machine learning, and presents results through a working web application.

The system should:

- Analyze live or recorded video feeds from safety-critical environments
- Detect whether individuals are wearing required safety gear:
    - Protective cap / helmet
    - Safety shoes
    - Protective eyewear (specs/goggles)
    - Masks
- Associate detected violations with individuals using face detection, tracking, or identification techniques.

- Log all safety compliance events with accurate timestamps
- Display insights through an admin dashboard

Domain Context

- The primary domain for this problem is:
    - Industrial safety (factories, shop floors, plants)
    - Laboratory safety (academic or research labs)
- Teams must choose and clearly specify their target domain (e.g., factory floor or laboratory).
- The core detection pipeline should remain generic and reusable, even if the demo focuses on a specific domain.

Functional Requirements

- Input:
    - Live webcam feed
    - Pre-recorded video feed simulating an industrial or lab environment (allowed for demo)
- Computer Vision & ML Requirements:
    - Detect human presence and safety equipment (helmet/cap, shoes, goggles/specs,mask).
    - Associate the individual with face detection, tracking or identification techniques.
    - Identify missing safety gear per individual
    - Handle multiple individuals in a single frame (preferred)
- Web Application Requirements(A functional web application that includes):
    - Video feed display (live or recorded)
    - Visual indicators or overlays showing safety compliance status.
    - An admin dashboard displaying:
        1. Detection logs
        2. Compliance / violation statistics
        3. Date and time of detection
- Data Storage:
    - The system must store safety compliance records containing:
        1. Person identifier (ID or embedding reference)
        2. Detected safety equipment
        3. Missing safety equipment
        4. Timestamp
        5. Video or camera source
        6. And other required data.

Expected Deliverables

- Working AI System:
    - ML model(s) used for detection
    - Inference pipeline for video input
- Web Application
    - Frontend and backend (any tech stack)

    - Admin dashboard
- Short solution presentation (template will be provided on the day of hackathon) along with a live demo.

Constraints & Rules

Model Usage

- Use of pretrained models (e.g., YOLO, SSD, Faster R-CNN, CNNs with transfer learning) is allowed.
- Using ready-made commercial PPE detection or surveillance SaaS APIs is not allowed.
- Fully black-box AI solutions without explanation are not allowed.

Development Rules

- Participants may use:
    - Publicly available datasets
    - Self-collected datasets
    - A combination of multiple datasets
- A functional web interface demonstrating the solution is mandatory.
    - The application may:
        - Run locally, or
        - Be deployed on a cloud platform (optional).
    - Production-grade scalability is not required; focus should be on correctness and clarity.
- Direct copying of complete solutions or repositories is prohibited.

Evaluation Focus

- Machine Learning & Computer Vision Effectiveness

  Correctness and robustness of safety gear detection (helmet/cap, shoes, goggles/specs) under realistic conditions.

- Individual Association Logic

  Effectiveness of associating detected safety violations with individuals using face detection, tracking, or identification techniques.

- System Architecture & Integration

  Quality of the end-to-end pipeline, including data flow from video input to detection, logging, and dashboard visualization.

- Web Interface & Dashboard Clarity

  Functionality, clarity, and usability of the web application and admin dashboard for monitoring compliance events.

- Practicality & Real-World Relevance

  Feasibility of the solution in industrial or laboratory environments, including handling of common challenges and stated limitations.

- Innovation & Thoughtfulness

  Novel ideas, meaningful enhancements, or thoughtful design choices that improve robustness, usability, or scalability.