IBM HACK CHALLENGE 2023

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PROJECT NAME:

SafetyNet.

Video Link

TABLE CONTENTS

1.INTRODUCTION

1.1 OVERVIEW

SafetyNet is a comprehensive industrial safety and surveillance system designed to enhance workplace safety and security. Leveraging live video streams from multiple areas within an industrial environment, it utilizes advanced computer vision and machine learning algorithms and IOT sensors to monitor worker compliance with safety gear, detect signs of fire, gas leaks and recognize distress signals. By providing real-time alerts and notifications to both workers and supervisors, SafetyNet aims to minimize workplace accidents, ensure prompt responses to emergencies, and improve overall safety conditions in industrial settings.

1.2 PURPOSE

The purpose of "SafetyNet" is to enhance safety and security in industrial environments through advanced video surveillance and monitoring. It serves to:

Ensure Worker Safety: By detecting and promoting the correct usage of safety gear (hard hats, safety vests, masks), SafetyNet helps reduce workplace accidents and ensure compliance with safety protocols.

Harmful Gas Detection: By detecting any harmful gases that may leak due to some malfunction may be hazardous to the workers, detecting this and issuing an alert would help curb it.

Fire Detection: The system actively monitors for signs of fire, enabling rapid response to potential emergencies and minimizing damage to property and harm to personnel.

Worker Distress Recognition: SafetyNet can identify distress signals from workers, enabling immediate assistance and potentially saving lives in hazardous situations.

Real-Time Alerts: Through real-time alerts and notifications, the project keeps both workers and supervisors informed about safety status, incidents, and emergencies.

Data and Compliance: SafetyNet maintains records and ensures compliance with safety regulations, contributing to a safer work environment and supporting regulatory requirements.

2. LITERATURE SURVEY:

2.1 EXISTING PROBLEM:

Industrial safety is of paramount importance, given the potentially hazardous environments of manufacturing plants, construction sites, and industrial facilities. A literature review reveals several key challenges and issues in industrial safety:

Accident Rates: Research consistently highlights high accident rates in industrial settings. These accidents result in injuries, fatalities, and significant economic losses.

Safety Gear Compliance: Ensuring that workers consistently wear the required safety gear is a persistent challenge. Studies underline the importance of monitoring safety gear usage.

Fire Detection: Traditional fire detection systems are limited in their ability to quickly identify fires in large industrial spaces.

Gas leakage: Gas sensors are not widely used to monitor if any gases have leaked in the premises, this is an important issue.

Worker Distress: Recognizing worker distress signs or emergencies in real-time is a crucial yet challenging task.

Response Time: Reducing response time during emergencies is critical. Delays in detecting and responding to incidents can have dire consequences.

2.2 Proposed solution

To address the aforementioned challenges in industrial safety, an integrated solution, such as "SafetyNet," offers promising prospects:

Advanced Computer Vision: Leveraging computer vision and deep learning, as proposed "SafetyNet" can accurately monitor worker safety gear compliance, including hard hats, safety vests, and masks, through real-time video analysis.

Fire Detection Algorithms: Modern fire detection algorithms, can be integrated into "SafetyNet" to identify early signs of fires, such as smoke and temperature anomalies, and trigger immediate alerts to mitigate potential disasters.

Gas leakage detection: IOT sensors placed all over the premises would keep checking the levels of harmful gases in the air, if the amount exceeds the low limit, then an alert is to be issued to all personell to evacuate the premises.

Worker Distress Recognition: The incorporation of computer vision-based worker distress recognition, enables "SafetyNet" to promptly identify and respond to signs of worker distress,

improving emergency response times.

Real-Time Alerts: By providing real-time alerts and notifications to both workers and supervisors, "SafetyNet" ensures that safety-related information is communicated promptly, enabling quick decision-making.

Data and Compliance: A comprehensive data logging and compliance management system, ensures that safety standards and regulatory requirements are met and documented.

3.THEORETICAL ANALYSIS

3.1 Analysis

The primary objective of "SafetyNet" is to significantly enhance workplace safety and security in industrial settings. It aims to achieve this by monitoring and ensuring compliance with safety gear requirements, detecting potential fire hazards, recognizing worker distress signals, and providing real-time alerts to both workers and supervisors. This comprehensive approach intends to reduce accidents, minimize response times during emergencies, and improve overall safety conditions.

Computer Vision and Deep Learning:
"SafetyNet" relies on computer vision techniques, including object detection and recognition, to analyze live video streams from industrial cameras. Deep learning models, such as Convolutional Neural Networks (CNNs), play a pivotal role in identifying and tracking objects of interest, including workers and safety gear items. These models have the capability to accurately determine if workers are wearing hard hats, safety vests, and masks, as well as recognize specific gestures indicating distress.

Fire Detection Algorithms:
The system incorporates advanced fire detection algorithms capable of identifying early signs of fires, such as smoke, flames, or unusual temperature patterns, in industrial environments. These algorithms employ image analysis and thermal sensing to trigger immediate alerts, facilitating rapid responses to potential fire incidents. The timely detection of fires can prevent catastrophic consequences and safeguard both lives and assets.

Worker Distress Recognition:
"SafetyNet" employs computer vision techniques to recognize specific signs or gestures indicating worker distress. This capability allows the system to promptly identify when a worker is in danger or requires assistance. By automating distress recognition, the system enhances worker safety and contributes to a proactive safety culture within the workplace.

Real-Time Alerts and Communication:
A cornerstone of the system is its ability to provide real-time alerts and notifications. Workers and supervisors receive immediate alerts through various communication channels, including email, SMS, and push notifications. These alerts ensure that safety-related information is rapidly conveyed to the relevant parties, enabling quick decision-making and response during critical events.

Data Management and Compliance:
SafetyNet maintains a robust data management system for storing video recordings and event logs. This data serves multiple purposes, including auditing, analysis, and compliance verification. By documenting safety incidents and gear compliance, the system assists in meeting regulatory requirements and improving safety standards over time.

3.2 Hardware / Software designing Software Requirements:

IBM Cloud Object Storage

Python

OpenCV

Tensorflow

YOLO (You Only Look Once) v8

Flask (for web interface)

React

Raspberry Pi

MQ135 sensor

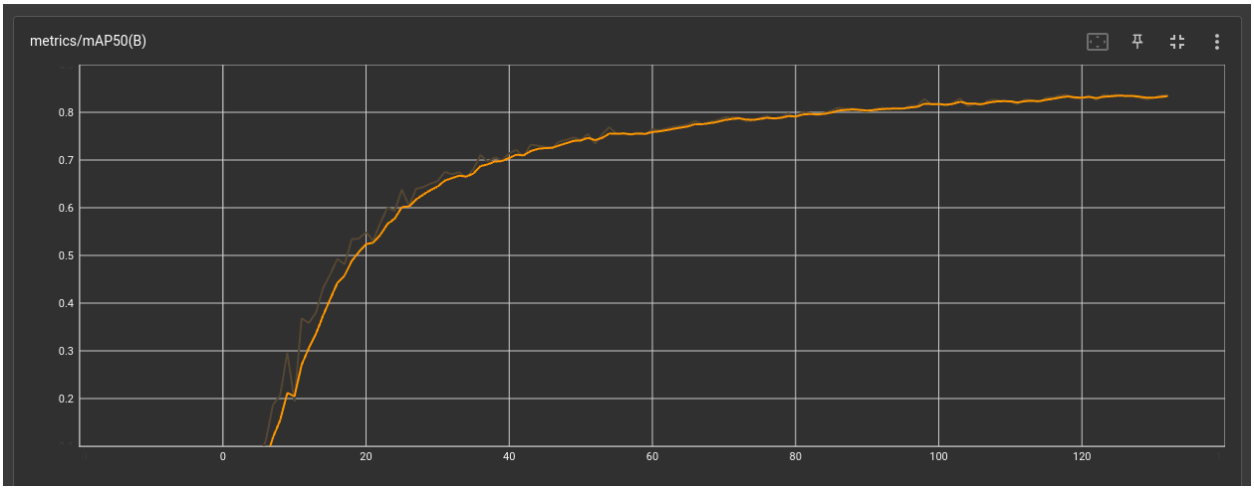
4.EXPERIMENTAL INVESTIGATION

4.1 Safety Gear Detection

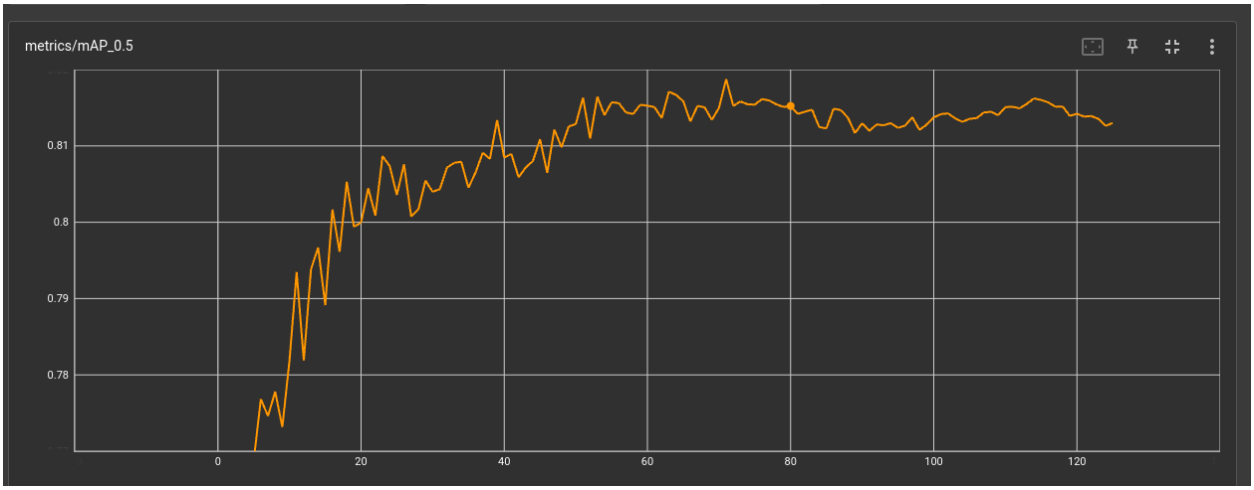
1. Class labels:
[Hardhat, Mask, NO-Hardhat, NO-Mask, NO-Safety Vest, Person, Safety Cone,
Safety Vest, machinery, vehicle]
The model that was used in order to train this model was the yolov8l model. It consists of 268 layers and 43,668,288 parameters. The model needs approximately 165 GFLOPS of compute power to run. The model was trained on a custom dataset with the aforementioned classes and the hardware that was required to train that model was: 2x Nvidia Tesla T4 GPUs with 16gb VRAM each, 30GB of RAM and 4v CPU compute Engine.

The model was trained for 310 epochs and took a total amount of time of nearly **36 hrs to train** completely.

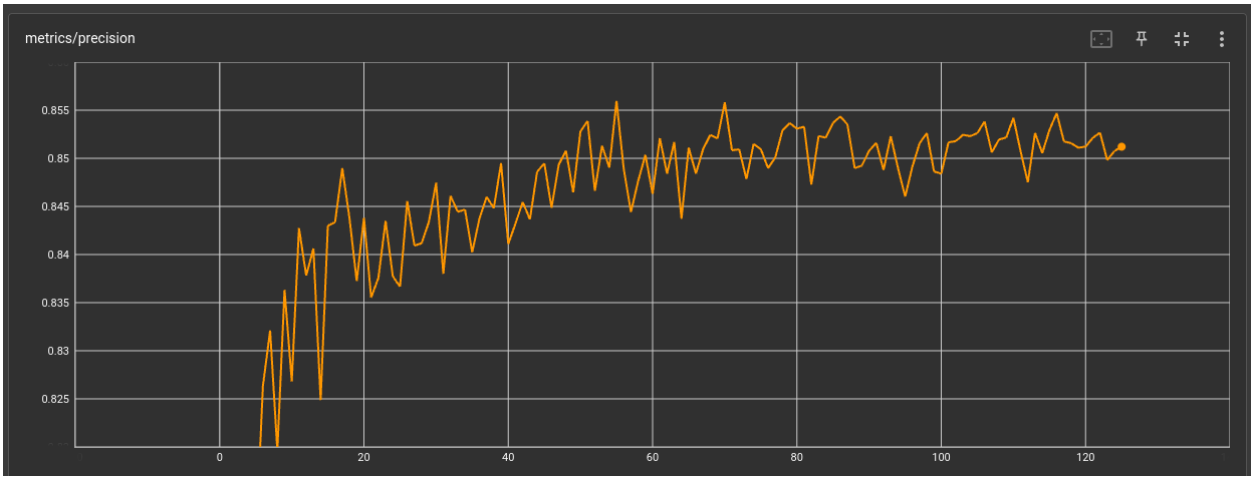
2. Model Metrics:
a. mAP50 (B):



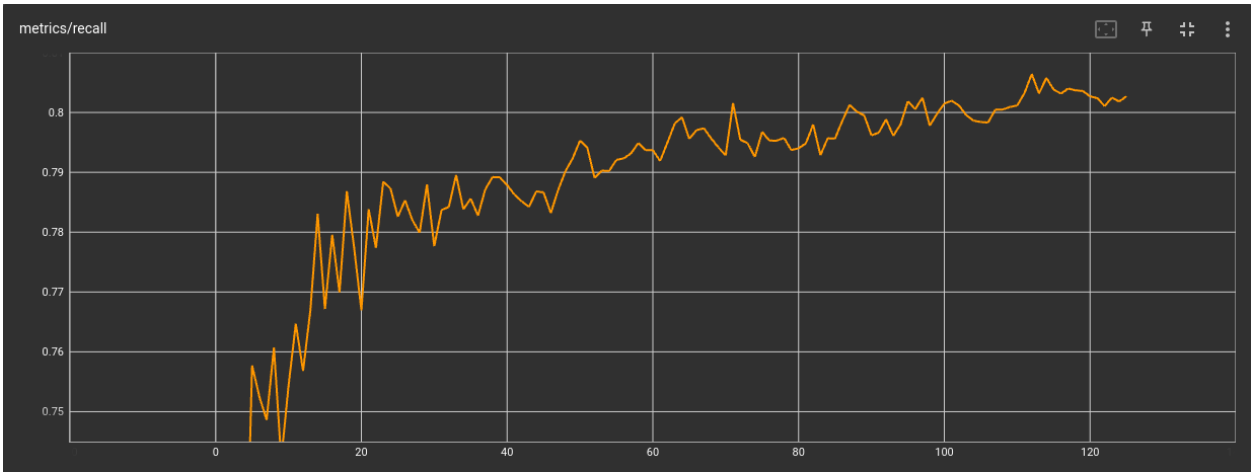
b. mAP_0.5:



c. Precision:



d. Recall:



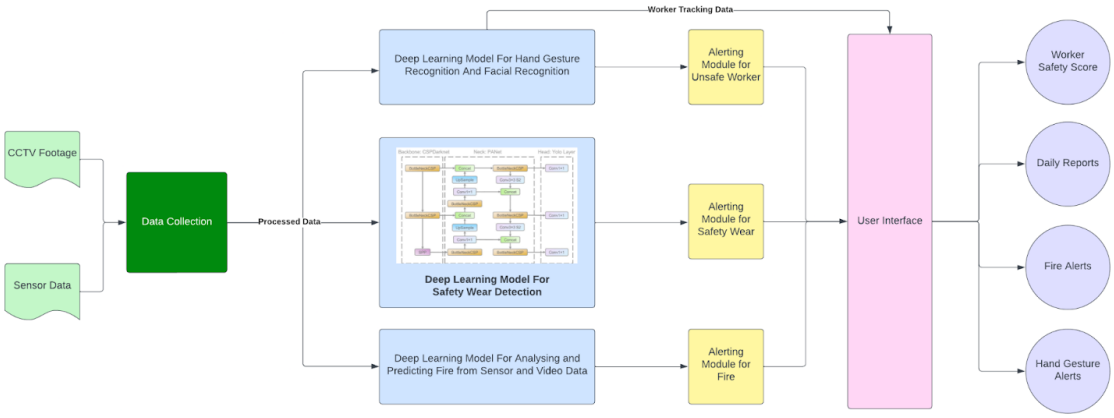
4.2 Fire Detection

This model is a fine-tuned version of google/vit-base-patch16-224-in21k. It achieves the following results on the evaluation set:

Loss: 0.0126
Precision: 0.9960
Recall: 0.9960

Training Loss	Epoch	Step	Validation Loss	Precision	Recall
0.1018	1.0	190	0.0375	0.9934	0.9934
0.0484	2.0	380	0.0167	0.9961	0.9960
0.0357	3.0	570	0.0253	0.9948	0.9947
0.0133	4.0	760	0.0198	0.9961	0.9960
0.012	5.0	950	0.0203	0.9947	0.9947
0.0139	6.0	1140	0.0204	0.9947	0.9947
0.0076	7.0	1330	0.0175	0.9961	0.9960
0.0098	8.0	1520	0.0115	0.9974	0.9974
0.0062	9.0	1710	0.0133	0.9960	0.9960
0.0012	10.0	1900	0.0126	0.9960	0.9960

5. FLOWCHART:


Worker Tracking Data
CCTV Footage
Sensor Data
Data Collection
Processed Data
Deep Learning Model For Hand Gesture Recognition And Facial Recognition
Deep Learning Model For Safety Wear Detection
Deep Learning Model For Analysing and Predicting Fire from Sensor and Video Data
Alerting Module for Unsafe Worker
Alerting Module for Safety Wear
Alerting Module for Fire
User Interface
Worker Safety Score
Daily Reports
Fire Alerts
Hand Gesture Alerts

6. OUTPUT / RESULT :

Landing Page

Our Goal

SafetyNet is a comprehensive industrial safety and surveillance system designed to enhance workplace safety and security. Leveraging live video streams from multiple areas within an industrial environment, it utilizes advanced computer vision and machine learning algorithms and IOT sensors to monitor worker compliance with safety gear, detect signs of fire, gas leaks and recognize distress signals. By providing real-time alerts and notifications to both workers and supervisors, SafetyNet aims to minimize workplace accidents, ensure prompt responses to emergencies, and improve overall safety conditions in industrial settings.

Our technologies that benefit you

Safety Gear Detection

Workers could be monitored to check if they are wearing safety gear like helmets, gloves, etc.

Hand Gesture Recognition

Workers could use hand gestures to control machines, or to alert authorities in case of an emergency.

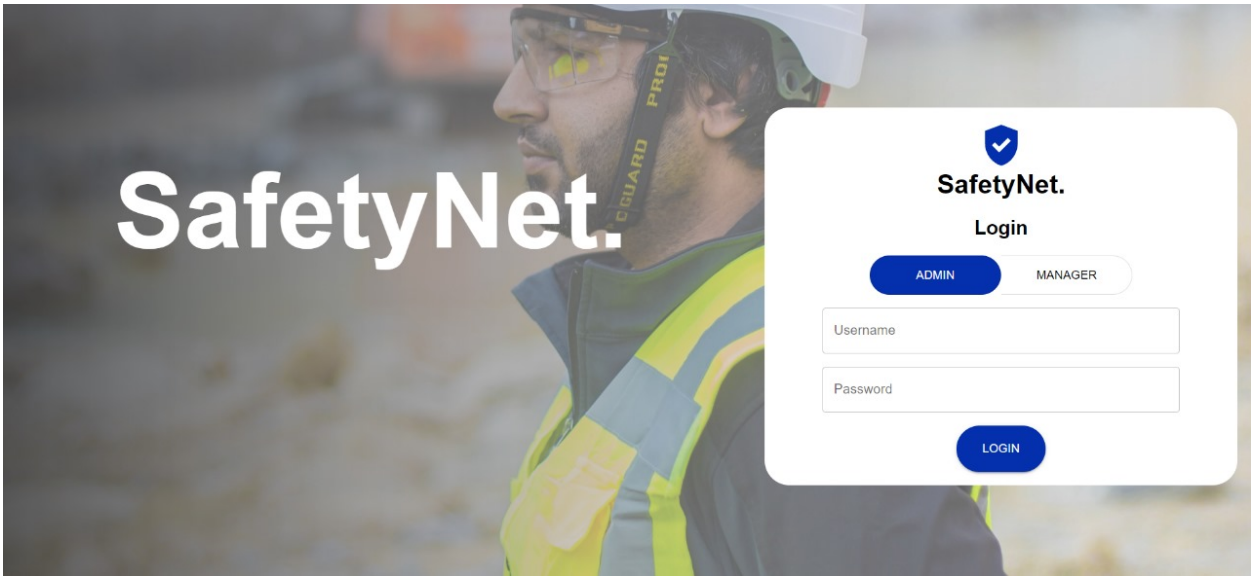
Fire Detection

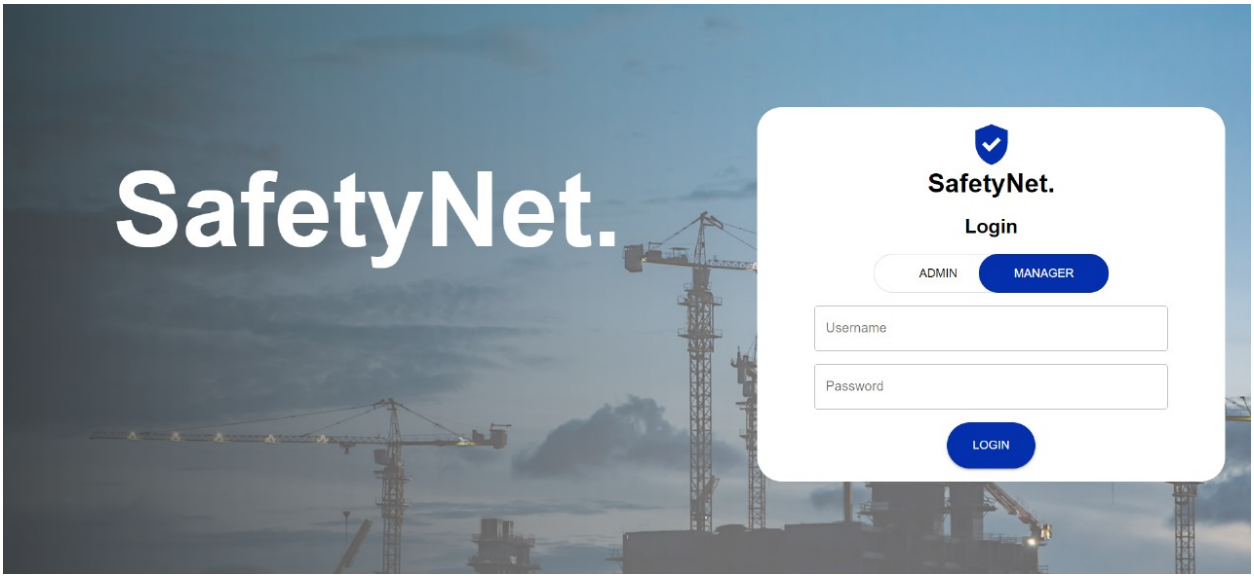
Factory Fires could be detected and prevented using this module and avoided using immediate alerts

Sensor Data

Temperature, Humidity, Pressure, etc. could be monitored using sensors and alerts could be sent in case of any abnormality

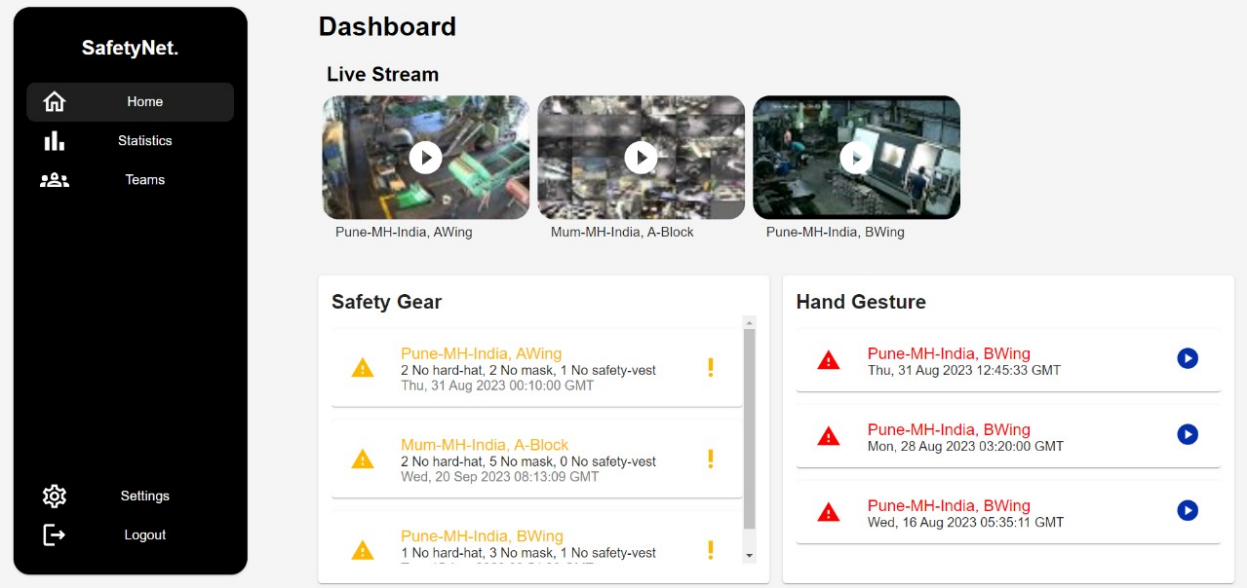
Admin & Manager Login

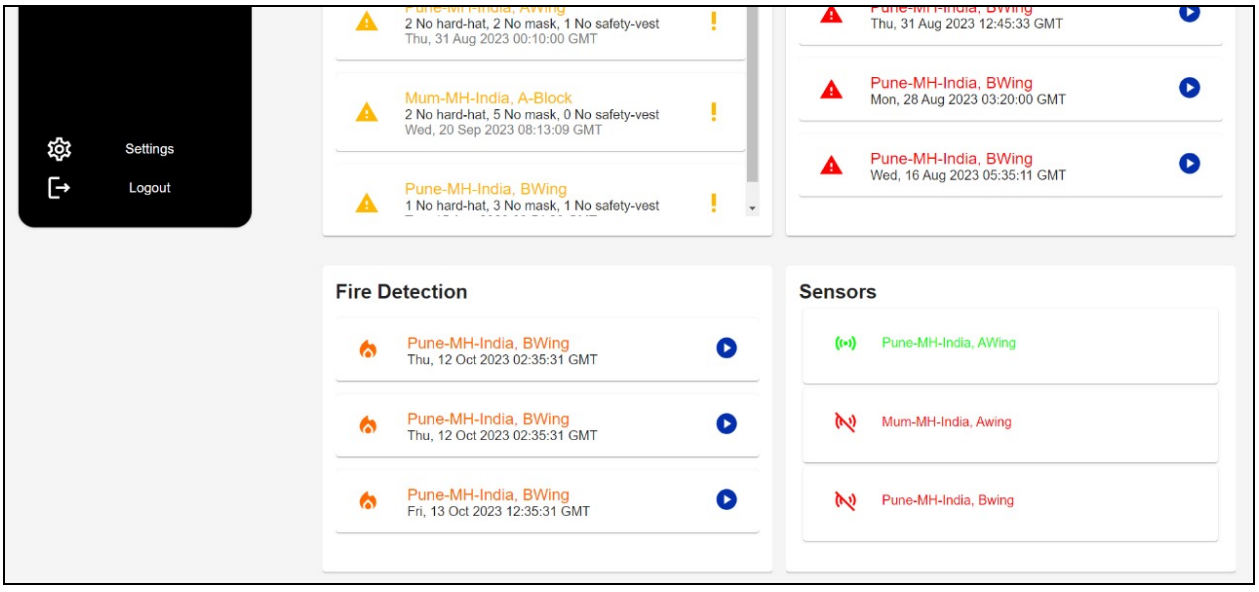




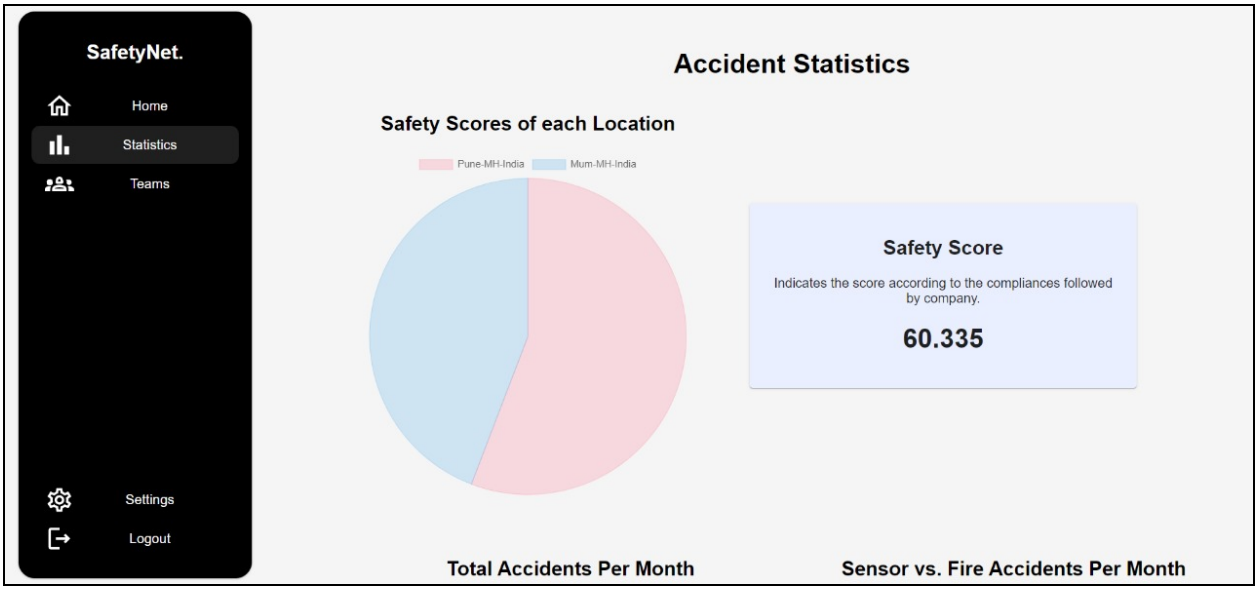
Admin Dashboard

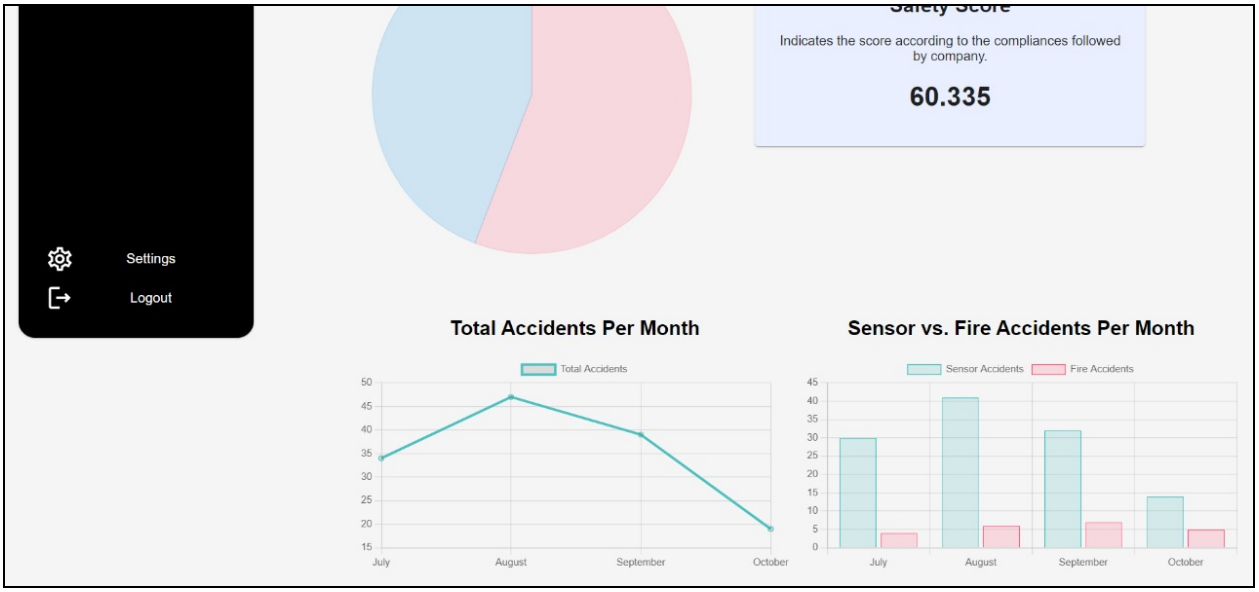
It consists of Organization wide data, i.e. data collected from all the factories / industrial sites are crunched together for the admin of the organization to observe.





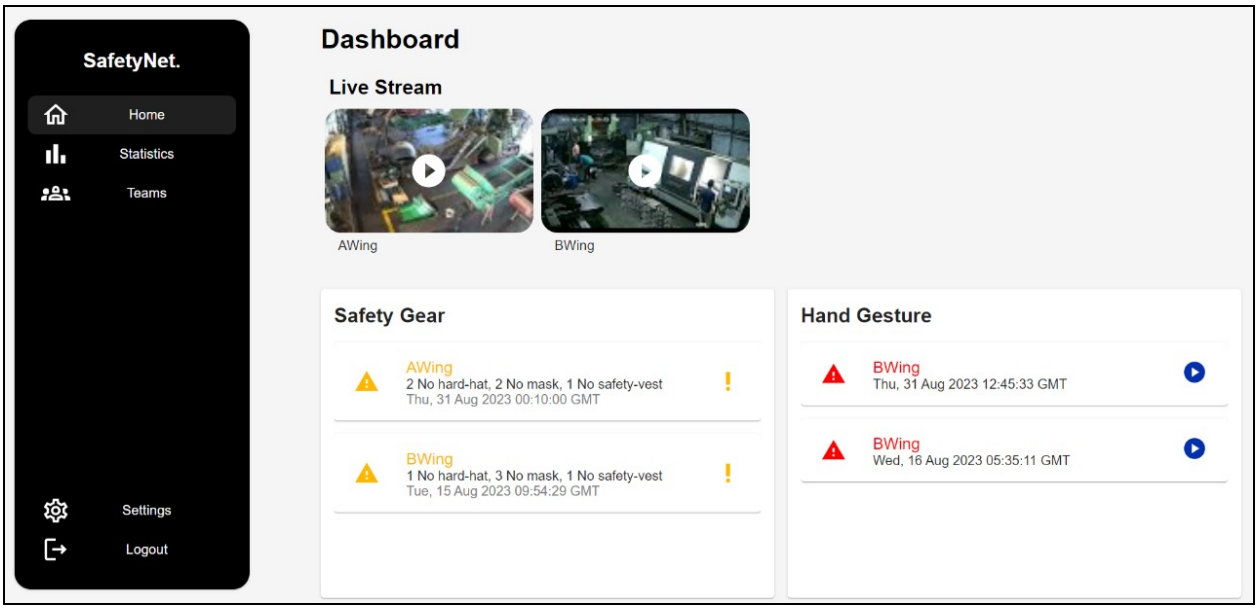
The admin dashboard also has access to analytics and stats related to the safety of the industrial sites, the graphs of safety-scores, fire-incidents and harmful gas sensor alerts

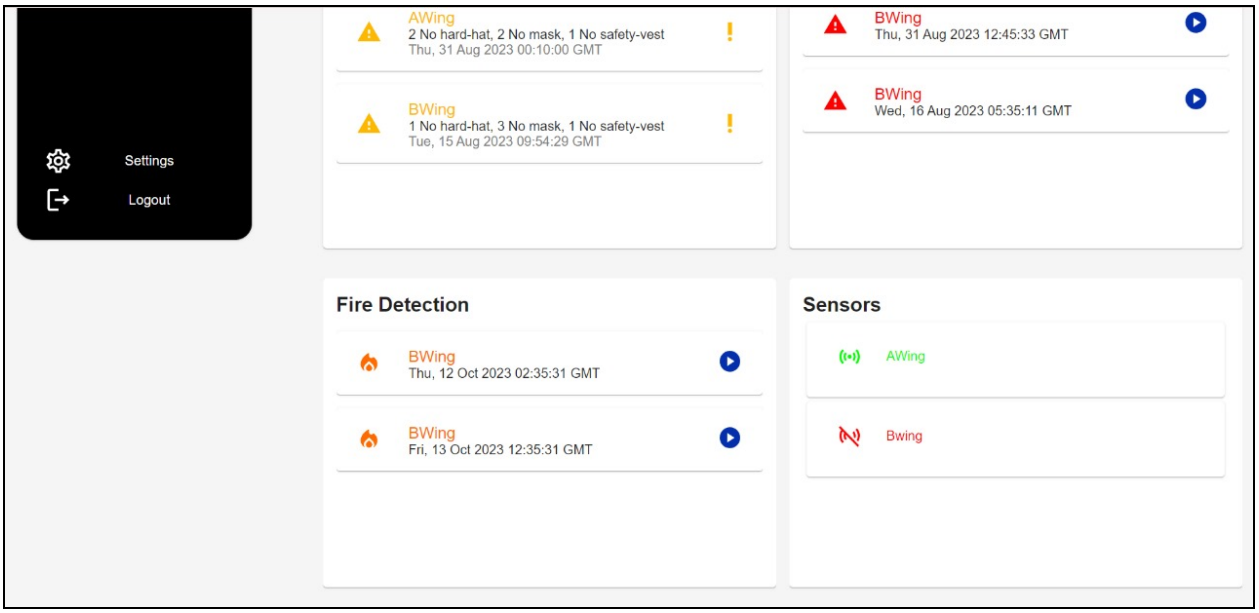




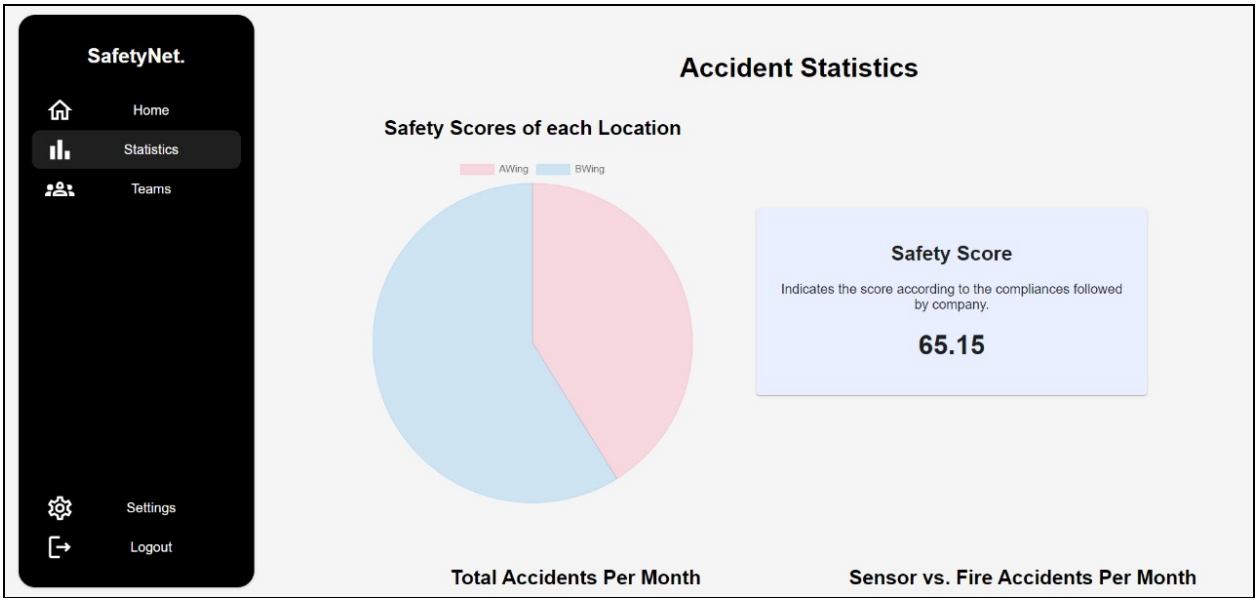
Manager Dashboard

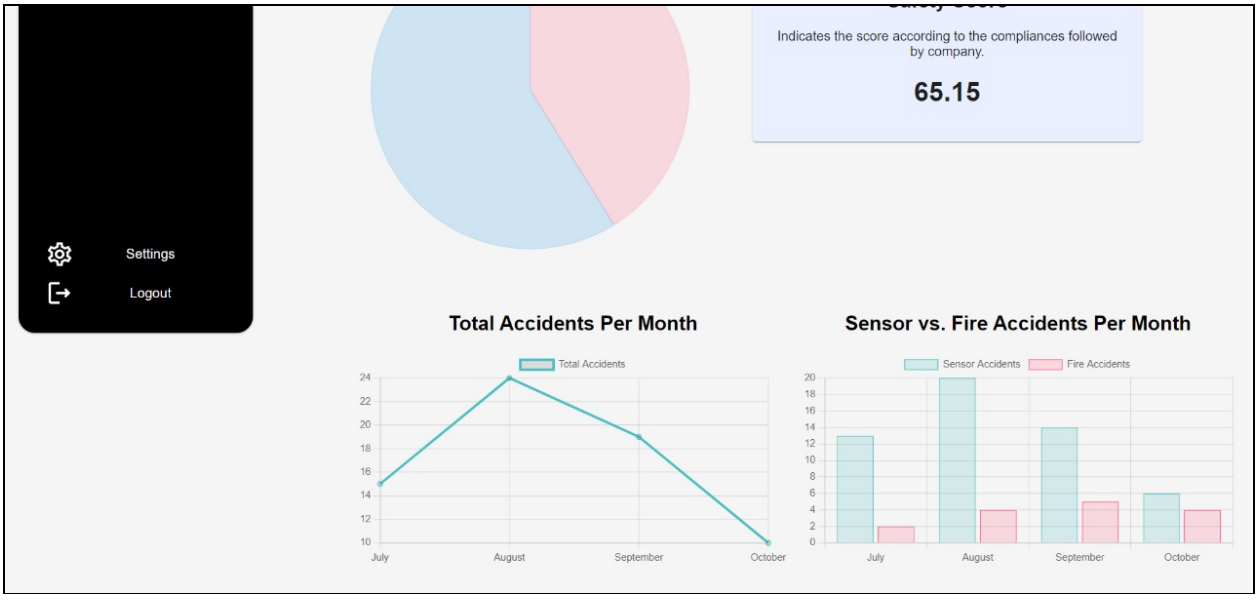
It consists of Factory / Industrial area wide data, i.e. data collected from that particular factory or industrial site is crunched together for the manager of the respective site to observe.





The manager dashboard also has access to analytics and stats related to the safety of the industrial sites, the graphs of safety-scores, fire-incidents and harmful gas sensor alerts





7. FEATURES:

Improved Worker Safety: "SafetyNet" ensures a safer working environment by monitoring and promoting the use of safety gear. Workers benefit from reduced accident rates and a culture of safety awareness.

Early Fire Detection: The system's fire detection algorithms swiftly identify potential fire hazards, allowing for early intervention and damage prevention.

Early Gas leakage detection: IOT sensors placed all over the premises would keep checking the levels of harmful gases in the air, if the amount exceeds the low limit, then an alert is to be issued to all personell to evacuate the premises.

Rapid Distress Response:"SafetyNet" recognizes worker distress signals, enabling immediate assistance and potentially saving lives during emergencies.

Real-Time Alerts:Real-time alerts and notifications keep workers and supervisors informed, facilitating quick decision-making and incident response.

Data for Compliance: The system's data management capabilities assist in regulatory compliance, ensuring adherence to safety standards and regulations.

8. APPLICATIONS

The "SafetyNet" system, designed to enhance industrial safety through advanced video surveillance and monitoring, has a wide range of applications across various industries and workplace environments. Here are some key applications:

Manufacturing Plants: "SafetyNet" can be deployed in manufacturing facilities to monitor worker safety, ensure compliance with safety gear requirements, and promptly detect any signs of fire or distress. It helps prevent accidents and maintains a safe production environment.

Construction Sites: In the construction industry, "SafetyNet" plays a crucial role in enhancing worker safety. It monitors construction sites in real-time, ensuring that workers wear appropriate safety gear and providing immediate alerts for potential hazards or emergencies.

Mining and Extractive Industries: In mining and extractive industries, worker safety is paramount. "SafetyNet" assists in tracking safety compliance, detecting signs of danger, and sending rapid alerts in the event of accidents or hazardous conditions.

Warehouses and Logistics Centers: Warehouses and logistics centers can benefit from "SafetyNet" by ensuring the safety of workers operating heavy machinery, such as forklifts, and by detecting and responding to fire incidents that could jeopardize valuable inventory.

Oil and Gas Facilities: In oil and gas refineries and facilities, "SafetyNet" contributes to fire prevention and early detection. It also plays a role in monitoring workers' safety while handling hazardous materials.

Chemical and Pharmaceutical Plants: "SafetyNet" ensures safety compliance in chemical and pharmaceutical manufacturing, helping prevent accidents and chemical spills. It aids in the rapid identification of potential fire or safety hazards.

Power Plants and Utilities: The system can be employed in power generation facilities to monitor safety gear usage and detect early signs of equipment malfunctions or overheating that could lead to electrical fires.

Construction Safety Training: "SafetyNet" can be used for training purposes in construction and industrial settings. It records and evaluates workers' adherence to safety protocols, providing valuable feedback for training programs.

Emergency Response Centers: Emergency response centers can utilize "SafetyNet" to receive real-time information about safety incidents, enabling them to dispatch resources quickly and efficiently.

Government and Regulatory Bodies: Government agencies and regulatory bodies can use the data collected by "SafetyNet" for safety compliance audits and industry-wide safety assessments.

Research and Safety Analysis: "SafetyNet" generates valuable data that can be used for safety analysis, incident investigations, and research on workplace safety trends.

Customized Industrial Applications: "SafetyNet" can be tailored to meet the safety needs of specific industries and workplaces, making it a versatile solution for a wide range of industrial settings.

9. CONCLUSION:

In conclusion, "SafetyNet" emerges as a transformative force in the realm of industrial safety, representing a significant leap forward in safeguarding workers and assets. Its integration of state-of-the-art technologies, including computer vision, machine learning, and real-time alerts, has the potential to redefine safety paradigms across diverse industries. By instilling a culture of safety, ensuring compliance with safety gear, detecting fire hazards, and recognizing worker distress signals, "SafetyNet" proactively mitigates risks, making workplaces safer and more secure.

As we navigate the path to implementing "SafetyNet" in industrial settings, we embrace the promise it holds—the promise of fewer accidents, swifter responses during emergencies, and ultimately, the well-being of workers and the preservation of industrial assets. "SafetyNet" stands as a testament to the enduring commitment to industrial safety excellence, where innovation becomes the cornerstone of progress, ushering in an era where safety is not just a practice but a way of life in the industrial landscape.

10. FUTURE SCOPE:

While "SafetyNet" represents a groundbreaking advancement in industrial safety, its future scope envisions even greater impact and evolution. In the coming years, the project is poised to extend its capabilities by incorporating emerging technologies such as augmented reality (AR), and enhanced data analytics. Augmented reality will play a pivotal role in training and incident response, offering immersive safety simulations and guided procedures. Furthermore, advanced data analytics will provide deeper insights into safety trends and predictive modeling, allowing proactive measures to prevent accidents before they occur.

Beyond technological enhancements, "SafetyNet" aims to foster international collaboration to standardize safety protocols and regulations. By aligning with global safety initiatives, the project can set benchmarks for safety compliance and facilitate the exchange of best practices among industries worldwide. Additionally, "SafetyNet" envisions partnerships with research institutions and academia to drive continuous innovation in the field of industrial safety, ensuring that it remains at the forefront of safety excellence. Ultimately, the future of "SafetyNet" transcends its current state as a project; it aspires to become a holistic ecosystem where safety is not only practiced but continuously redefined and elevated to new heights.