



Workers Monitoring And Safety Assurance Bot In Oil Refinery Using ESP32 CAM

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Abstract: Workers monitoring and safety assurance bot in oil refinery using esp32 CAM introduces an intelligent surveillance and safety monitoring system using a mobile robot built on ESP32 architecture. It features real-time face recognition, environmental monitoring, and emergency response capabilities, controlled via a mobile application with automated alert systems. Designed to enhance workplace safety, particularly in hazardous environments like oil refineries, the system detects hazardous gases, temperature fluctuations, and motion anomalies, providing live video feeds and alerts to a central hub. Leveraging low-cost IoT technology, it aims to reduce workplace accidents, improve incident response times, and ensure compliance with safety regulations, making it a scalable and adaptable solution for industrial safety.

Index Terms - Workers Monitoring, Safety Assurance, ESP32-CAM, IoT-Based Surveillance, Face Recognition, Environmental Monitoring, Industrial Safety, Real-Time Alerts, Wireless Communication, Hazard Detection, Remote Monitoring, Autonomous Surveillance Bot.

I. INTRODUCTION

The project presents an autonomous robot-based surveillance system designed to enhance industrial safety and security monitoring using ESP32 architecture, Python-based computer vision, and various sensors. It addresses the limitations of traditional surveillance systems, which often lack mobility and real-time response capabilities. Targeting high-risk environments like oil refineries, where toxic gases, flammable substances, and high temperatures pose significant safety threats, the system offers real-time face recognition, environmental monitoring, and remote-control features. Leveraging the low-cost ESP32-CAM with integrated camera and Wi-Fi, the bot monitors worker activity, detects hazardous conditions, and transmits data to a centralized system for prompt action, enhancing adaptability and accident prevention in dynamic industrial settings.

II. LITREATURE SURVEY

[1] The IoT-Powered Smart Surveillance Sentinel Bot is an advanced security system designed to enhance real-time surveillance using IoT sensors and communication modules. It integrates sensors for continuous data collection, including video and motion detection, while leveraging cloud or edge computing for efficient activity analysis. The bot features autonomous navigation with GPS and obstacle avoidance, ensuring seamless mobility in various environments. A real-time alert mechanism notifies users of any suspicious activities, while a user-friendly interface enables remote monitoring and control. This system enhances security by providing continuous surveillance, reducing human intervention, and enabling instant response to potential threats, making it a cost-effective and efficient solution for modern security challenges.

[2] The Sensing-Aware Deep Reinforcement Learning With HCI-Based Human-in-the-Loop Feedback for Autonomous Nonlinear Drone Mobility Control presents an advanced approach to optimizing drone navigation in complex environments. This system leverages deep reinforcement learning (DRL) to enhance autonomous mobility while integrating human-in-the-loop (HCI) feedback for improved control accuracy and decision-making. Equipped with real-time environmental sensing, the drone continuously adapts to changing conditions, ensuring better situational awareness. The training process involves a dynamic interaction between human feedback and autonomous learning, allowing the control system to refine its navigation strategies over time. By continuously adapting its learning algorithm, the drone enhances its responsiveness and maneuver ability in nonlinear and unpredictable environments. This approach significantly improves drone adaptability, optimizes decision-making, and ensures precise navigation, making it a highly effective solution for autonomous mobility in dynamic settings.

[3] The Face Recognition Using ESP32-Cam for Real-Time Tracking and Monitoring system presents an efficient and cost-effective approach to facial recognition and surveillance. Utilizing the ESP32-Cam module, the system captures real-time facial images and applies face detection algorithms to identify individuals. To ensure quick recognition, facial processing and matching are performed locally on the ESP32, reducing dependence on external servers and minimizing latency. Once a face is identified, the system continuously tracks and monitors the individual in real time. Additionally, an integrated user interface displays tracking results and provides instant alerts when necessary. This solution offers a compact and affordable surveillance system with high accuracy and reliability, making it suitable for real-time security applications requiring continuous monitoring.

[4] The ALATS: Analysis of Localization Algorithms in Terrestrial Surveillance Bots study examines and evaluates various localization algorithms to enhance the positioning accuracy of terrestrial surveillance bots. By implementing different techniques such as GPS, dead reckoning, and sensor-based methods, the research compares the performance in real-world environments. The analysis focuses on key factors such as accuracy, efficiency, and reliability, providing valuable insights into the strengths and limitations of each approach. Based on the findings, the study offers recommendations for optimizing localization strategies in surveillance bots, ensuring improved navigation and operational effectiveness. This work contributes to enhancing surveillance efficiency by identifying the most reliable and precise localization methods for diverse environments.

[5] The Development of an Affordable Real-Time IoT-Based Surveillance System Using ESP32 and TWILIO API presents a cost-effective approach to real-time security monitoring. Utilizing the ESP32, the system captures surveillance data, including video and sensor readings, and transmits it to a cloud-based server for processing and storage. The integration of the TWILIO API enables instant notifications via SMS or email whenever security events are detected, ensuring prompt responses. A user-friendly interface allows remote monitoring and control, enhancing accessibility and ease of use. Designed for affordability and scalability, this system can be easily deployed across various environments, making it a practical solution for real-time surveillance applications.

[6] The Multi-Sensor Surveillance System Based on Integrated Video Analytics presents an advanced approach to security monitoring by integrating multiple sensors, such as cameras, motion detectors, and temperature sensors, for comprehensive surveillance. Real-time video feeds are processed using video analytics algorithms, while data from various sensors is combined to enhance event detection and situational awareness. Machine learning models further refine the system's ability to detect anomalies or potential threats with greater accuracy. A centralized monitoring system is implemented to manage sensor data, issue alerts, and facilitate efficient decision-making. This multi-sensor integration significantly improves surveillance efficiency by providing a more intelligent and context-aware security solution.

[7] The Computer Vision and IoT-Enabled Bot for Surveillance and Monitoring of Forests and Large Farms leverages IoT sensors and computer vision technologies to enhance real-time monitoring in vast natural environments. Equipped with cameras and sensors, the bot collects crucial data, such as detecting movement and environmental changes, to ensure continuous surveillance. Advanced image processing algorithms enable object recognition and anomaly detection, improving the accuracy of threat identification. By integrating these technologies, the system provides an efficient and automated solution for monitoring large-scale areas, making it valuable for environmental protection, wildlife tracking, and agricultural security.

[8] The Design and PoC Implementation of Mm-Wave-Based Offloading-Enabled UAV Surveillance System introduces a high-speed UAV surveillance framework leveraging millimeter-wave (mm-wave) communication for efficient data transfer. The system incorporates offloading mechanisms that distribute data processing tasks between the UAV and ground stations, optimizing computational efficiency. Mm-wave links enable real-time video streaming and large data transfers, ensuring seamless surveillance operations. The architecture is designed to support UAV autonomy, mobility, and dynamic data offloading, enhancing operational flexibility. A Proof-of-Concept (PoC) implementation validates the system's performance, emphasizing communication efficiency and surveillance effectiveness, making it a robust solution for high-speed, real-time aerial monitoring.

[9] The Cam-Aspect: An Intelligent Automated Real-Time Surveillance System With Smartphone Indexing presents an innovative approach to surveillance by utilizing smart phones for real-time video capture. Automated image and video analysis algorithms detect and index events, enhancing monitoring efficiency. The system integrates facial recognition and object detection technologies to improve identification accuracy. A cloud-based indexing mechanism ensures efficient storage and retrieval of surveillance data, enabling quick access to relevant footage. Additionally, a user-friendly interface provides remote monitoring capabilities and event notifications, making this system a cost-effective and intelligent solution for real-time security and surveillance applications.

[10] The Design and Implementation of an Intelligent Autonomous Surveillance System for Indoor Environments introduces a smart monitoring solution that leverages sensors and cameras for real-time indoor surveillance. The system employs object detection and tracking algorithms to identify and follow individuals or objects, enhancing security and situational awareness. Machine learning models analyze and classify detected activities or anomalies, ensuring accurate and efficient threat detection. Additionally, autonomous movement and navigation capabilities enable comprehensive coverage of indoor spaces. A user-friendly interface facilitates remote monitoring and system management, providing real-time alerts and seamless control. This intelligent surveillance system offers an advanced and automated approach to indoor security.

[11] The IoT-Guard: Event-Driven Fog-Based Video Surveillance System for Real-Time Security Management presents a robust security solution that leverages IoT and fog computing for efficient surveillance. The system captures real-time video data from multiple cameras and employs event-driven triggers to activate video processing and security event detection. By utilizing fog computing, data is processed locally, reducing latency and minimizing bandwidth consumption. Edge devices are integrated for real-time analysis, enabling quick responses to potential security threats. A centralized monitoring system facilitates remote access for efficient security management, making this approach highly effective for real-time surveillance and threat mitigation.

[12] The Control Architecture of Delivery Robot for Supporting Nursing Staff introduces an autonomous delivery robot designed to assist health care professionals in hospital environments. Equipped with sensors and actuators, the robot navigates autonomously while efficiently managing task scheduling and movement coordination. Obstacle detection mechanisms ensure smooth navigation, minimizing disruptions in hospital workflows. A remote monitoring and control system allows nursing staff to manage delivery tasks with ease, enhancing operational efficiency. Additionally, the robot features a communication interface that seamlessly integrates with existing hospital systems, facilitating smooth interaction and improving overall healthcare support services.

III. METHODOLOGY

The implementation of the Workers monitoring and safety assurance bot in oil refinery using Esp32 CAM follows a structured methodological approach, integrating both hardware and software components for efficient surveillance and monitoring. The hardware integration involves the ESP32 microcontroller as the central control unit, coordinating the functionality of DC motors for robot movement. Various sensors, including gas, fire, and temperature sensors, are deployed to detect hazardous conditions in the refinery environment. An ESP32-CAM module is incorporated to enable real-time video streaming, while a Bluetooth module facilitates connectivity with a mobile application for enhanced control and monitoring. On the software development side, a Python-based face recognition application utilizing the Haar cascade algorithm

is implemented to identify individuals in the surveillance area. An Android application is developed to provide manual control over the robot's navigation, ensuring flexibility in operations. Additionally, instant Telegram notifications based on detected events, enhancing real-time situational awareness. The ESP32 firmware is programmed for seamless sensor integration, enabling accurate data acquisition and transmission. Furthermore, appropriate communication protocols are implemented to ensure smooth interaction between hardware and software components, creating a reliable and responsive surveillance system.

3.1 Block Diagram

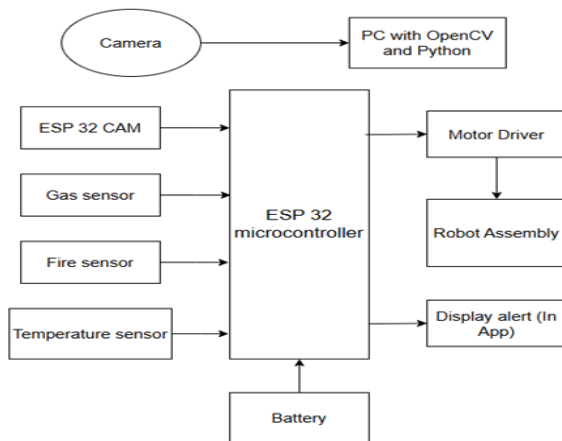


Fig.1 Block diagram of safety assurance bot

3.2 WORKING

The Workers monitoring and safety assurance bot in oil refinery operates through an integrated workflow comprising face recognition, robot operation, communication, and alert mechanisms. The Face Recognition System continuously captures video through a laptop camera, utilizing the Haar cascade algorithm to detect faces. If an unknown face is identified, an alert is triggered, prompting the robot to take necessary action. The Robot Operation includes autonomous movement based on predefined commands, real-time environmental parameter monitoring, and alert displays in the Android application. Additionally, manual control through the mobile app allows users to navigate the robot as needed. The Communication System ensures seamless connectivity via WIFI, facilitating Telegram notifications and real-time video streaming for remote monitoring. The Alert System plays a crucial role in security by sending immediate Telegram notifications for unknown face detections and displaying alerts in the app for environmental anomalies. The system also performs real-time parameter monitoring and threshold checking, ensuring proactive safety measures in hazardous environments.

3.3 OBJECTIVES

1. Implement real-time face recognition using Haar cascade algorithm
2. Develop wireless communication between the laptop and robot using HC12 module
3. Integrate multiple sensors for environmental monitoring
4. Create Android application for manual robot control
5. Implement emergency notification system through Telegram
6. Enable live video streaming through ESP-CAM
7. Ensure reliable data transmission and system response

3.4 FLOW CHART

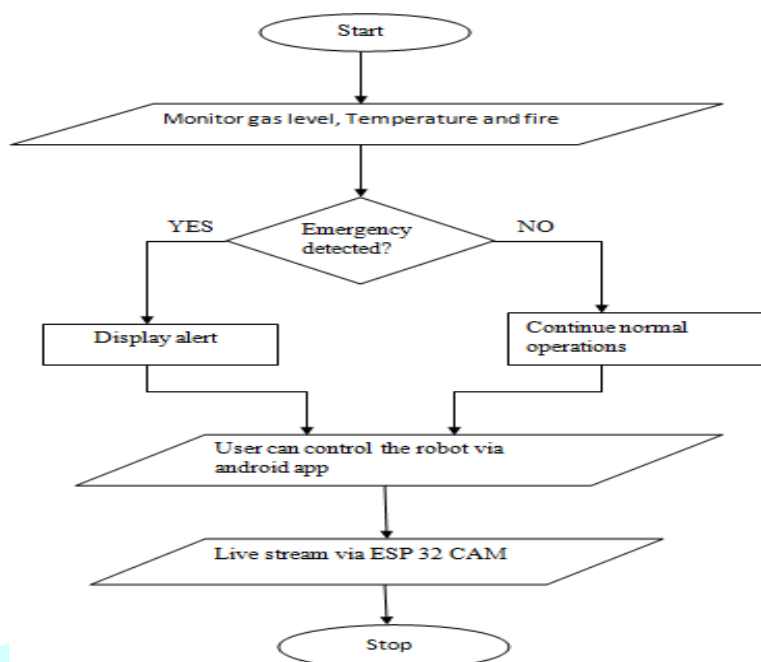


Fig.2 Hardware flowchart of the safety assurance bot using ESP 32 CAM.

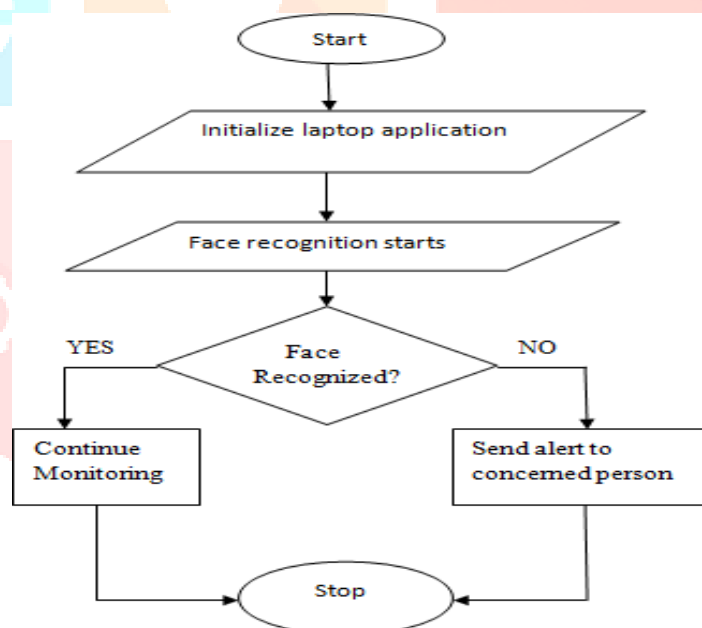


Fig.3 Software flowchart for real time face recognition.

IV. RESULTS

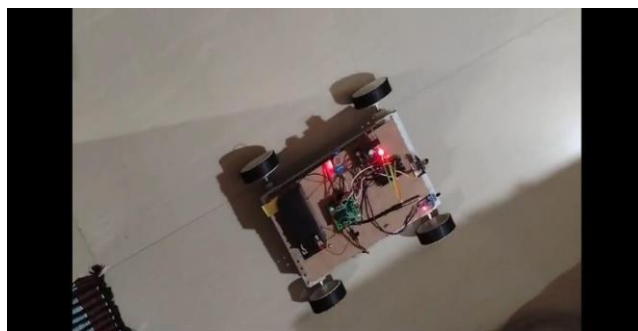


Fig.4 Workers monitoring safety assurance bot

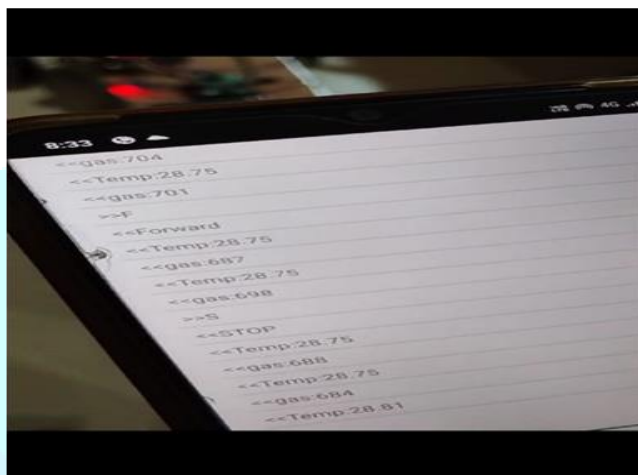


Fig.5 Reading of temperature, gas and fire sensor

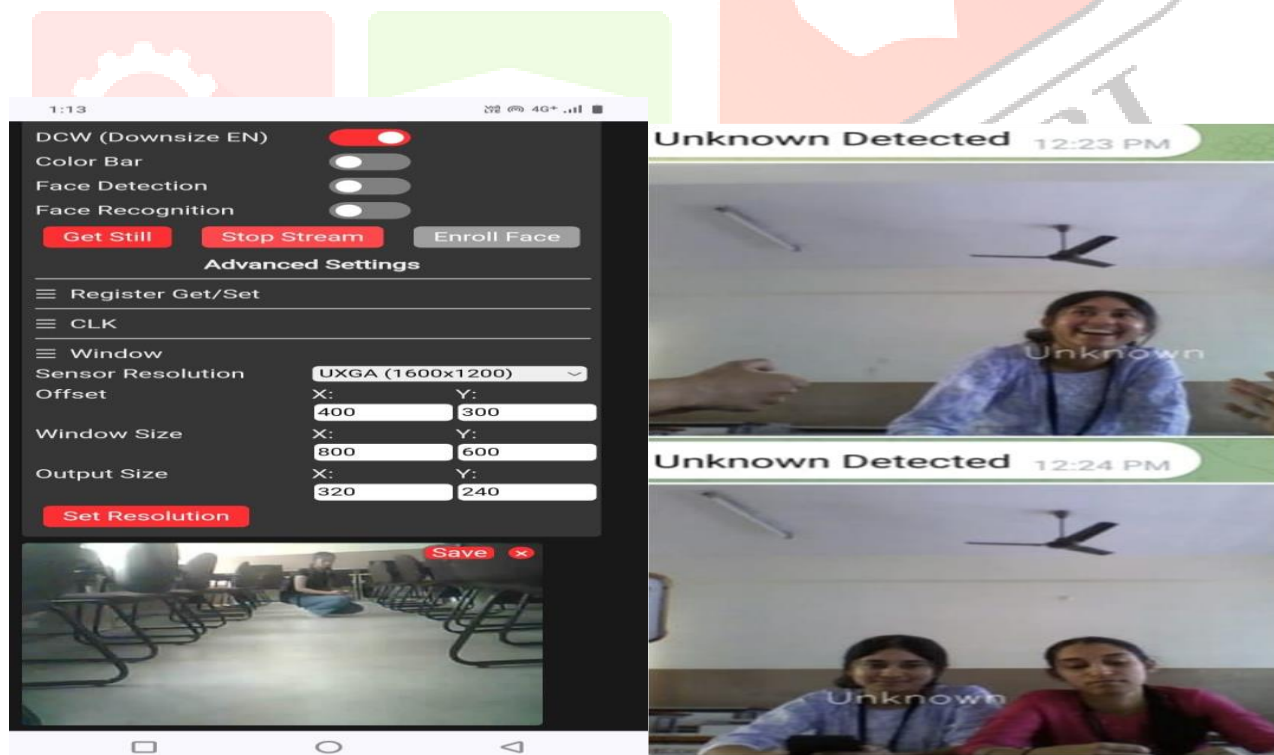


Fig.6 Image of livestream from ESP 32 CAM and the image of face recognizing detection

CONCLUSION

The Worker Surveillance and Safety Bot represents a significant advancement in workplace safety and security monitoring. The integration of multiple technologies creates a robust, mobile surveillance system capable of real-time monitoring and response. The system's ability to detect unauthorized personnel, monitor environmental parameters, and provide immediate alerts makes it an effective solution for industrial safety applications. Future enhancements could include AI-based decision making and expanded sensor integration. The implementation of the Worker Surveillance and Safety Assurance Bot using ESP32-CAM is a major step forward in ensuring workplace safety, particularly in high-risk industries. By integrating face recognition, environmental monitoring, and real-time alerts, this bot significantly enhances surveillance and reduces workplace hazards. One of the major advantages of this system is its cost-effectiveness, making automated industrial safety monitoring accessible to various industries. Unlike traditional surveillance systems, the mobility of the bot allows for dynamic monitoring, covering areas that static cameras cannot.

Future developments could focus on:

AI-driven predictive analysis for risk assessment and anomaly detection.

Enhanced sensor integration for more accurate environmental data collection.

Battery optimization techniques for improved operational time. •

Integration with industrial IoT (IIoT) systems for centralized monitoring and control.

APPLICATION

Oil Refineries:

The bot ensures worker safety by monitoring hazardous conditions such as gas leaks, fire, and extreme temperatures. o Provides real-time alerts for emergency response and reduces accidents.

Helps in compliance with industrial safety regulations.

Chemical Plants:

Detects toxic gas emissions and provides early warnings to prevent exposure related illnesses.

Enhances surveillance in high-risk areas where human monitoring is challenging.

Agricultural and Farming Automation

Detects intrusions or unauthorized access to farm areas.

Monitors environmental conditions to optimize farming operations.

FUTURE SCOPE

Integration of AI and machine learning for predictive safety analysis and automated risk detection.

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