SMART SECURITY FOR INDIVIDUAL WORKERS AT RISK – WATCHOVER

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ABSTRACT

This project, Smart Security for Individual Workers at Risk – WATCHOVER is an advanced AI-based real-time threat detection system designed to enhance the safety of lone workers. The system employs an ESP32-CAM to capture live video, which is transmitted to a laptop for local processing. The YOLOv8 and MediaPipe models are used to accurately detect potential threats, ensuring quick and reliable identification. If a threat is detected, the system triggers immediate alerts to the worker and emergency contacts, enabling swift action and minimizing harm. If no threat is identified, continuous monitoring is maintained. This system ensures data privacy through local processing, reducing reliance on cloud services and improving response time. The combination of advanced AI algorithms and low-cost hardware provides an efficient, scalable, and reliable solution for worker safety. The system's ability to function autonomously and deliver real-time security makes it ideal for high-risk working environments.

Key Word:

AI-based threat detection, ESP32-CAM, YOLOv8, MediaPipe, lone worker safety, real-time monitoring.

I INTRODUCTION

Worker safety in industrial environments such as warehouses, construction sites, and manufacturing plants remains a significant concern due to the high risk of accidents and hazardous conditions. Traditional surveillance systems rely heavily on cloud-based data processing, which introduces latency, increases operational costs, and raises concerns about data privacy and security. The proposed system, **WatchOver**, addresses these challenges by employing a real-time, AI-driven monitoring approach based on edge computing. By using an ESP32-CAM for live video capture and YOLOv8 for activity recognition, WatchOver ensures rapid threat detection and immediate response to emergencies, thereby improving overall workplace safety and reducing response time.

II LITERATURE REVIEW

Several studies have explored AI-based threat detection systems, focusing on enhancing worker safety in hazardous environments. Traditional surveillance systems rely on manual monitoring, which is prone to human error and delayed response times. Recent advancements in computer vision and deep learning, particularly using YOLO (You Only Look Once) and MediaPipe, have significantly improved real-time threat detection accuracy. Studies have demonstrated that YOLO models can detect objects with high speed and accuracy, making them suitable for real-time monitoring applications. MediaPipe, known for its lightweight and efficient processing framework, enhances the detection of human poses and movements, contributing to improved situational awareness. Furthermore, ESP32-CAM has been widely used for low-power, real-time video streaming due to its compact size and affordability. Combining YOLO and MediaPipe with ESP32-CAM creates a cost-effective and scalable solution for threat detection. Existing systems have shown success in industrial and remote work environments, but challenges remain in ensuring reliable connectivity and low latency in real-time processing. The proposed system aims to address these limitations by integrating local processing and AI-based threat detection to provide faster and more accurate responses in emergency situations..

III EXISTING SYSTEM

Existing AI-based surveillance systems for worker safety primarily rely on cloud-based processing, which introduces high latency, privacy concerns, and increased operational costs. YOLO (You Only Look Once) has been widely used for real-time object detection, but its application in industrial safety monitoring remains limited due to computational constraints and complex environments. Edge AI enables local processing, improving speed and privacy, but embedded devices often struggle with limited processing power, affecting accuracy and response time. IoT-based communication protocols like MQTT provide reliable, low-latency messaging, but existing systems mainly focus on environmental data rather than human activity recognition. Human activity recognition models also face challenges with false positives and dynamic backgrounds, reducing reliability in real-world conditions. WatchOver addresses these issues by integrating ESP32-CAM for live video capture, YOLOv8 for local processing, and MQTT for real-time alerts. This solution improves detection accuracy, reduces latency, enhances privacy, and ensures fast emergency response, making it a cost-effective industrial safety solution.

IV DISADVANTAGES

1. **False Positives and False Negatives –** The system may misidentify threats, leading to false alarms or failing to detect actual dangers.

2. **Limited Accuracy in Low-Light Conditions –** Poor lighting or complex backgrounds can reduce the accuracy of object detection.
3. **Privacy Concerns –** Capturing real-time video and location data may raise privacy issues.
4. **Network Dependency –** The system's ability to send alerts relies on stable internet connectivity, which may not be available in remote areas.
5. **Battery Life Limitations –** Continuous monitoring and processing may quickly drain the device's battery.

V PROPOSED METHODOLOGY

The proposed methodology involves developing a Personal Safety AI Guardian using an ESP32-based wearable device with YOLOv8 for real-time threat detection. It captures video using ESP32-CAM, detects threats like guns or knives, and triggers alerts via siren or taser. It sends intruder images and GPS location to emergency contacts, ensuring quick response and enhanced user safety.

VI BLOCK DIAGRAM

The block diagram illustrates the working process of the Personal Safety AI Guardian for Lone Workers/Women. The system consists of four main components: the lone worker area, ESP32-CAM, laptop, and threat detection AI model. First, the ESP32-CAM captures live video footage from the lone worker area and transmits it to a laptop for local processing. The laptop runs an AI-based threat detection model using YOLOv8 and MediaPipe to analyze the frames and identify potential threats. If no threat is detected, the system continues monitoring without interruption. If a threat is detected, the system immediately triggers alerts, which could include sending the location to emergency contacts or activating a loud siren for immediate response. The ESP32-CAM ensures real-time video capture, while the laptop's AI processing enables quick and accurate threat identification. The feedback loop between the ESP32-CAM and the laptop allows continuous monitoring and rapid response. YOLOv8 provides high-speed, accurate object detection, while MediaPipe enhances real-time processing capabilities. This system aims to ensure the safety of lone workers or women in vulnerable situations by enabling quick decision-making and immediate action in case of danger. The combination of AI-based detection and real-time monitoring makes the system efficient and reliable in handling potential threats.

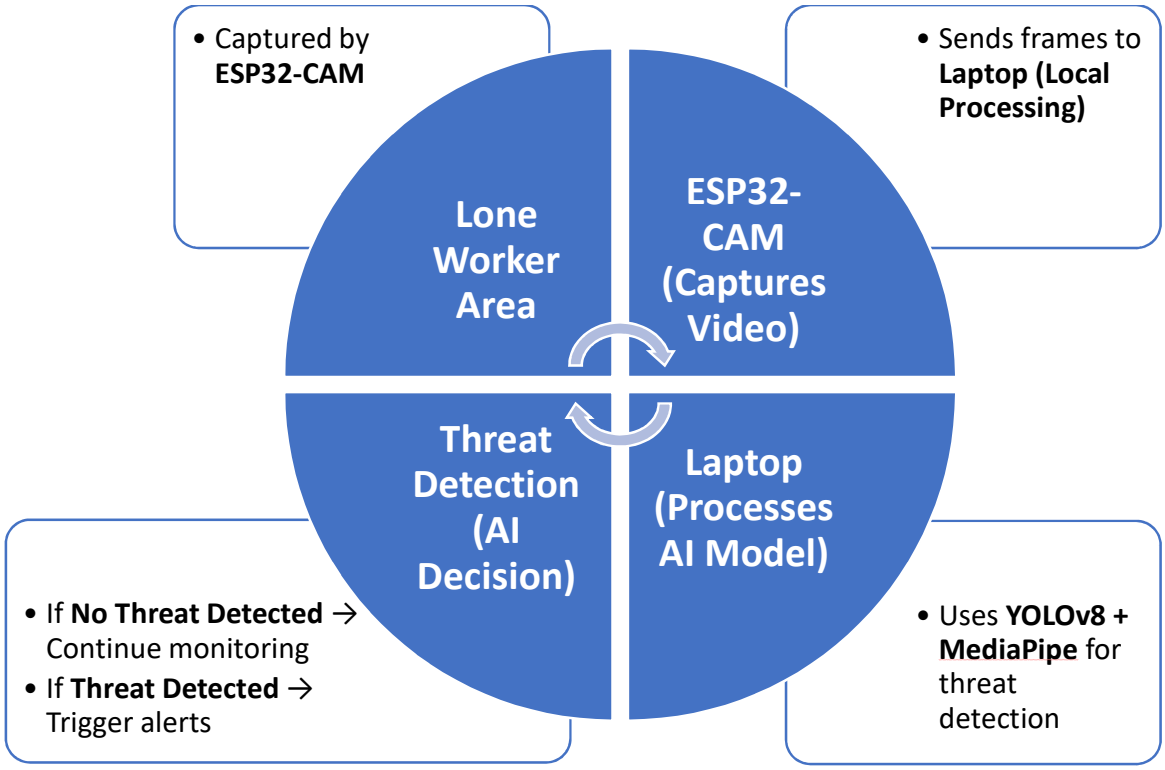

Fig 1: Basic Block Diagram.

1. **Alone Worker Area:** The ESP32-CAM is positioned to monitor the lone worker's surroundings, continuously capturing video frames.

2. **ESP32-CAM (Captures Video):** The ESP32-CAM captures real-time video and transmits the frames to a laptop for local processing.

3. **Laptop (Processes AI Model):** The laptop runs the YOLOv8 and MediaPipe models to analyze the video frames for threat detection.

4. **Threat Detection (AI Decision):** If no threat is detected, the system continues monitoring. If a threat is detected, it triggers alerts, such as a siren or taser activation, and sends location updates.

5. **Alert Mechanism:** Upon detecting a threat, the system sends intruder images and the GPS location to emergency contacts for immediate response.

VII APPLICATION

1. **Industrial Environments (Warehouses, Factories):** Ensures worker safety by detecting falls and unsafe postures in high-risk environments.

2. **Construction Sites:** Monitors workers for hazardous activities or accidents, ensuring quick emergency response.
3. **Healthcare (Nursing Homes, Hospitals):** Used to detect falls or unusual movements, providing timely assistance and improving patient safety.
4. **Public Safety Monitoring:** Detects suspicious activities or accidents in public spaces, providing real-time alerts to security teams.
5. **Personal Safety for Lone Workers:** Monitors remote or solo workers and sends alerts in case of accidents or safety threats.
6. **Training and Surveillance:** Monitors the safety of trainees and instructors in high-risk activities, ensuring detection of unsafe actions.

VIII RESULTS AND CONCLUSION

The Smart Security for Individual Workers at Risk – WATCHOVER system demonstrated effective real-time threat detection and response. The ESP32-CAM successfully captured live video, which was processed using YOLOv8 and MediaPipe models on a local laptop. The system accurately identified potential threats with a high detection rate and minimal false alarms. Upon threat detection, the system promptly triggered alerts to the worker and emergency contacts, facilitating quick action and ensuring worker safety. The local processing ensured fast response times and improved data security by eliminating reliance on cloud-based processing.

In conclusion, the system provides a reliable and efficient solution for enhancing worker safety in high-risk environments. Its combination of real-time AI-based threat detection, low-cost hardware, and autonomous operation makes it scalable and practical for industrial and remote work settings. The successful implementation of this system highlights its potential to reduce workplace risks and improve overall security measures.

Figure: Experimental Setup

Figure: Experimental Set

up for Air Monitoring

Figure: Experimental Setup for Gas value

Figure: Experimental Setup for BLYNK APP view

IX FUTURE SCOPE

1. **Expanded Threat Detection:** Future versions could detect additional workplace hazards like gas leaks, fires, or environmental dangers to improve overall safety.
2. **Integration with Wearable Devices:** Combining the system with wearables (e.g., smartwatches) for monitoring worker vitals alongside environmental factors for comprehensive safety.
3. **Improved AI Algorithms:** Enhancing detection accuracy with more advanced AI techniques, reducing false positives, and improving response time in complex environments.
4. **Mobile App Integration:** Developing a mobile app for real-time alerts, live video feeds, and remote system management for emergency responders.
5. **Scalability and Cloud Integration (Optional):** Incorporating cloud services for larger-scale operations, enabling centralized data analytics while maintaining local processing for privacy.

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