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AI BASED PERSON DETECTION AND ALERT SYSTEM IN RESTRICTED AREA USING RASPBERRY PI

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ABSTRACT

The AI-Based Person Detection and Alert System is a smart surveillance solution developed using Python on a Raspberry Pi to monitor restricted areas. The system captures real-time video through a camera module and processes it using Python-based libraries for image analysis. A lightweight deep learning model such as MobileNet SSD is implemented using TensorFlow Lite and OpenCV for efficient human detection. The system identifies unauthorized entry by defining a specific region of interest within the monitored area. When a person is detected inside the restricted zone, the system immediately triggers alerts such as sound alarms, email notifications, or mobile messages. Python is used for integrating all components including video processing, detection logic, and alert mechanisms. The system is designed to be cost-effective, energy-efficient, and suitable for continuous monitoring. It reduces the need for manual supervision while improving security and response time. The solution can be further enhanced with features like facial recognition, cloud connectivity, and real-time data logging. Future improvements may include IoT integration and advanced analytics for better accuracy. Overall, the system offers an automated, reliable, and scalable approach to security using Python-based implementation.

INDEX TERMS: Python, Person Detection, Raspberry Pi, Surveillance System, Artificial Intelligence, OpenCV, TensorFlow Lite.

I. INTRODUCTION

In recent years, the rapid advancement of artificial intelligence and embedded systems has significantly transformed the field of security and surveillance. Modern monitoring systems are increasingly adopting intelligent technologies to improve real- time detection, automation, and response in sensitive and restricted areas. An AI-Based Person Detection and Alert System is an important solution that helps in identifying unauthorized human presence and ensuring safety in secured environments.

Many organizations and institutions face challenges in continuously monitoring restricted areas due to the need for constant human supervision and the risk of delayed response. Traditional surveillance systems often rely on manual observation, which can lead to human errors and inefficiency. Therefore, there is a growing need for an automated system that can detect and respond to potential intrusions effectively.

To address this problem, an AI-Based Person Detection and Alert System using Raspberry Pi is proposed as a cost-effective and efficient solution. The system uses a camera module to capture real-time video and applies machine learning techniques for detecting human presence. By defining a specific region of interest, the system can accurately identify intrusions within restricted boundaries.

Furthermore, the use of artificial intelligence enhances the system's accuracy and efficiency by minimizing false detections and enabling real-time decision-making. The combination of hardware and software technologies creates a reliable, low-cost, And Security Purpose. Overall, the AI-based person detection and alert system provides an effective approach to modern surveillance by automating monitoring tasks, improving response time, and ensuring better safety and security.

II. MOTIVATION

The increasing need for safety and security in homes, offices, and public areas has highlighted the limitations of traditional surveillance systems. These systems often rely on continuous human monitoring, which can be time-consuming, inefficient, and prone to human error. Additionally, high-end security solutions can be expensive and inaccessible for small-scale users. This project is motivated by the idea of developing a **low-cost, intelligent, and automated security system** that can operate in real-time without constant supervision. By using a compact device like the Raspberry Pi combined with camera modules and machine learning algorithms, the system can detect the presence of a person accurately and efficiently.

The motivation behind designing this system architecture is to create a **smart surveillance solution** that processes live video streams, identifies human activity, and triggers alerts instantly when necessary. Unlike conventional systems, this approach minimizes false alarms and ensures quick response through automated notifications such as alarms, messages, or image capture.

Furthermore, integrating artificial intelligence and computer vision techniques enhances detection accuracy and system reliability. The use of affordable hardware makes the solution scalable and suitable for various applications, including home security, restricted area monitoring, and industrial safety.

Overall, the system is driven by the goal of improving security through automation, reducing human effort, enabling real-time monitoring, and providing an efficient and cost-effective alternative to traditional surveillance systems.

III. OBJECTIVE

- To analyze existing surveillance and security systems to identify limitations such as high cost, dependency on manual monitoring, and lack of real-time alerts.
- To design and develop an intelligent system using Raspberry Pi that can detect human presence through a connected camera module.
- To implement machine learning and computer vision techniques for accurate and efficient person detection in real-time environments.
- To create a reliable alert mechanism that notifies users instantly through alarms, messages, or image capture when a person is detected.
- To ensure high accuracy in detection by reducing false positives and improving system reliability compared to traditional motion sensors.
- To provide continuous monitoring with minimal human intervention, enhancing automation in surveillance systems.
- To develop a user-friendly system that can be easily deployed low-cost, real-time, and automated security solution with an a homes, offices, and restricted areas. improved accuracy and reliability.
- To maintain proper data handling by securely storing an captured images or logs for future reference and analysis.
- To enable effective communication between the system and users through real-time notifications and alerts.

- To build a cost-effective and scalable solution that can be expanded with additional features such as face recognition, cloud storage, or remote monitoring.

IV. LITERATURE REVIEW

A literature survey, also known as a literature review, is an essential part of research that provides a detailed understanding of existing work related to a specific domain. It involves analyzing, comparing, and synthesizing previous studies, technologies, and methodologies to establish a strong foundation for the proposed system. In the context of an AI-based person detection and alert system, the literature survey helps in identifying existing surveillance techniques, their limitations, and the need for intelligent and automated solutions.

The rapid advancement in artificial intelligence, computer vision, and embedded systems has significantly improved the efficiency of modern security systems. Traditional surveillance methods mainly rely on continuous human monitoring, which is inefficient and prone to errors. Recent research focuses on automated detection systems that can identify human presence and trigger alerts in real time

Joseph Redmon et al., "You Only Look Once (YOLO)" This research introduced a real-time object detection system capable of detecting multiple objects, including humans, with high speed and accuracy. YOLO is widely used in person detection systems due to its ability to process images in a single pass, making it suitable for real-time applications.

- **Navaneeth Bodla et al., "Soft-NMS for Object Detection"** This paper proposed an improved non-maximum suppression technique to enhance object detection accuracy. It helps reduce false detections, which is crucial in surveillance systems for reliable person identification.
- **Raspberry Pi Foundation, "Embedded Vision Systems using RaspberryPi"**
  This work highlights the use of Raspberry Pi in building low-cost embedded vision applications. It demonstrates how Raspberry Pi can be integrated with cameras and AI models to perform real- time monitoring tasks efficiently.
- **Szeliski, R., "Computer Vision: Algorithms and Applications"**
  This study provides a comprehensive overview of computer vision techniques used in image processing and object detection. It forms the theoretical basis for implementing person detection systems.
- **Various Researchers, "AI-based Surveillance and Security Systems"**
  Recent studies focus on integrating machine learning models with IOT devices to create

smart surveillance systems. These systems can detect human activity, send alerts, and store data for analysis, improving overall security and automation.

The literature survey highlights that although several systems exist for surveillance, many are either expensive or lack real-time intelligent decision-making capabilities. This creates a need for a cost-effective and efficient solution using embedded systems and AI.

Thus, the proposed AI-based Person Detection and Alert System using Raspberry Pi aims to address these gaps by providing a

V. SCOPE INCLUDE

- **Real-Time Person Detection** –The system is capable of detecting human presence using AI and computer vision techniques, making it suitable for continuous monitoring in homes, offices, and restricted areas.
- **Automated Alert and Notification System** –It provides instant alerts through alarms, mobile notifications, or emails whenever a person is detected, ensuring quick response to potential threats.
- **Remote Monitoring and Control** –Users can access live video feeds and system controls remotely through web or mobile interfaces, increasing flexibility and convenience.
- **Image and Video Data Management** –The system captures and stores images or video clips during detection events, which can be used for evidence, analysis, or future reference.
- **Machine Learning Integration for Accuracy** –Advanced ML models are used to improve detection accuracy, reduce false alarms, and enhance system performance over time.
- **Scalability and Future Enhancements** –The system can be expanded to include features like face recognition, motion tracking, IoT integration, and cloud-based storage for more advanced applications.
- **Cost-Effective Security Solution** –By utilizing affordable hardware, it provides an economical alternative to traditional surveillance systems, making it accessible to a wider range of users.
- **Applications in Multiple Domains** –The system can be applied in residential security, industrial monitoring, smart cities, and public safety systems.

VI. REQUIREMENT ENGINEERING

Requirements Engineering plays a crucial role in the design and development of the AI-based Person Detection and Alert System. This system integrates hardware and software components such as a camera module, sensors, and the Raspberry Pi to perform real-time surveillance and detection tasks. It includes key features like live video monitoring, person detection, alert generation, and data storage.

Since the system involves real-time processing and intelligent decision-making, requirements engineering ensures clear definition, proper communication, and efficient implementation of all system functionalities. A structured approach to gathering, analyzing, and managing requirements helps in building a reliable, accurate, and high-performance security system.

Functional Requirements:

- The system should capture real-time video using a camera module connected to the Raspberry Pi.
- The system should detect the presence of a person using machine learning and computer vision algorithms.
- The system should generate alerts (alarm, notification, or message) when a person is detected.
- The system should capture images or short video clips during detection events.– Captures real-time video or images from the surroundings.
- The system should store captured data (images/videos) locally– Continuously sends visual data to the processing unit (Raspberryor on cloud storage. Pi).
- The system should allow users to monitor live video remotely – Acts as the primary input source for detection. through a web or mobile interface.
- The system should provide an option to start or stop
- **Person Detection Module** monitoring as required.

Non-Functional Requirements:

- **Usability:** The system should be simple and user-friendly, allowing users to easily set up, monitor, and control the surveillance system.
- **Reliability:** The system should provide accurate person detection with minimal false alarms and operate continuously without failure.
- **Scalability:** The system should support future enhancements such as face recognition, cloud integration, and multiple camera connections.

- **Security:** The system should ensure that stored data and alerts are secure and accessible only to authorized users.
- **Cost Efficiency:** The system should be affordable by using low- cost hardware components while maintaining effective performance.

VII. METHODOLOGY

- **Requirement Analysis:** Gather system requirements based on security needs such as real-time monitoring, person detection, and alert mechanisms. Identify hardware and software components required, including camera modules, sensors, and the Raspberry Pi.
- **System Design:** Design the system architecture by creating block diagrams and flowcharts. Define how components like the camera, Raspberry Pi, and alert system interact. Plan the integration of machine learning models for person detection.
- **Implementation:** Develop the system using Python along with libraries such as OpenCV and TensorFlow/YOLO for computer vision. Configure the Raspberry Pi with the camera module and implement the detection and alert functionalities.
- **Testing:** Perform unit testing for individual modules (camera, detection, alerts), integration testing for combined components, and system testing to ensure real-time performance, accuracy, and reliability.
- Uses computer vision and machine learning algorithms (e.g., OpenCV, YOLO). Processes incoming video frames to detect human presence. -Differentiates humans from other objects to reduce false detections.

Machine Learning Model

- Responsible for intelligent analysis of visual data.
- Improves detection accuracy over time through trained models.
- Supports real-time decision-making for identifying a person.

Alert and Notification System

- Triggered when a person is detected.
- Sends alerts via buzzer/alarm, SMS, email, or mobile notify.
- Ensures immediate response to potential security threats.

Image/Video Storage Module

- Captures and stores images or short video clips during detection events.

- Data can be stored locally (SD card) or on cloud storage.
- Useful for evidence and future analysis.

Remote Access and Control

- Allows users to access the system remotely via the internet.
- Users can monitor live feeds and manage alerts from anywhere.
- Enhances flexibility and usability.

VIII. SYSTEM ARCHITECTURE

System Initialization / Access

- This is the starting point of the system where the device is powered on and initialized.
- The Raspberry Pi loads the required software, camera drivers, and machine learning models.
- It ensures that all components are ready for real-time monitoring.

User Interface (UI) / Monitoring Dashboard

- Users interact with the system through a simple web or mobile interface.
- It allows users to view live video feeds, receive alerts, and control system functions (start/stop monitoring).
- Acts as a central hub connecting all modules.

Camera Module (Input Layer)

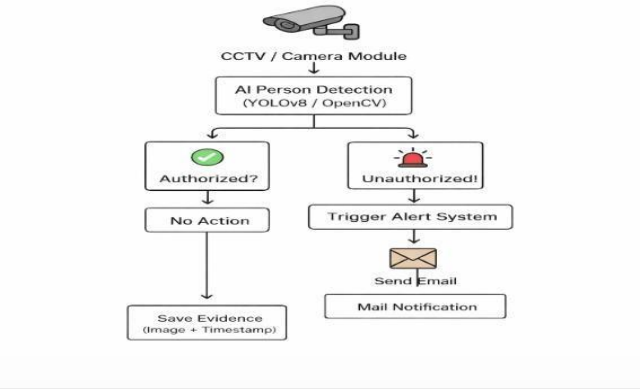

Fig. 1. System Architecture.

IX. APPLICATIONS

- **Home Security Systems:**Provides real-time monitoring and detects intruders in residential areas, ensuring safety through instant alerts.

- **Offices and Workplaces:**Monitors employee movement and prevents unauthorized access to restricted areas.
- **Banks and ATMs:** Enhances security by detecting suspicious activities and unauthorized persons around sensitive locations.

Educational Institutions: Ensures campus safety by features for better, monitoring and control.

Monitoring entry/exit points and detecting unknown

- **Improved AI Models:**Using advanced deep learning models can individuals.
- **Industrial Security Systems:**Protects factories and industrial further increase detection accuracy, reduce false alarms, and enable behavior analysis.
- areas by detecting unauthorized entry and preventing
- **Multi-Camera Support:**The system can be expanded to handle
- accidents.
- **Hospitals and Healthcare Centers:** Ensures restricted access to sensitive areas like ICUs and labs.
- **Military and Defense Applications:** Used for border surveillance and detection of intruders in high-security zones.
- **Parking Areas and Residential Societies:** Monitors vehicle entry points and enhances security in gated communities.

X. CONCLUSION

The AI-based Person Detection and Alert System using Raspberry Pi provides an effective and intelligent solution for modern security challenges. The system enhances surveillance by automating the process of detecting human presence and generating real-time alerts, reducing the need for continuous manual monitoring.

By integrating computer vision and machine learning techniques, the system ensures accurate detection and quick response to potential threats. Features such as real-time monitoring, email notifications, and image capture improve overall reliability and usability. The use of low-cost hardware makes the system affordable and accessible for various applications, including homes, offices, and public spaces.

In the future, the system can be further enhanced by incorporating advanced technologies such as facial recognition, cloud-based storage, IoT integration, and mobile application support. These improvements will increase system efficiency, scalability, and intelligence.

XI. FUTURE WORK

- **Facial Recognition Integration:** The system can be upgraded to identify specific individuals by integrating face recognition, allowing differentiation between authorized and unauthorized persons.
- **Cloud Storage and Data Management:** Captured images and videos can be stored on cloud platforms for secure access, backup, and remote monitoring from anywhere.
- **Mobile Application Support:** A dedicated mobile app can be developed to provide real-time alerts, live streaming, and system control directly from smartphones.
- **Smart Notifications:** Advanced alert systems can be implemented to send intelligent notifications via email, mobile apps, or push alerts with detailed information and images.
- **IOT Integration:** The system can be connected with other smart devices like smart locks, lights, or alarms to automate responses when a person is detected.
- **Video Streaming and Remote Surveillance:** Enhance the system with high-quality live streaming and remote access multiple cameras for monitoring large areas like campuses, offices, or industrial zones.

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