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AI-Driven Intelligent Autonomous Surveillance and Women Safety System

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Abstract: Urban security and personal safety have become critical challenges due to increasing crime rates and limitations of traditional surveillance systems. Conventional CCTV-based monitoring and manual patrolling rely heavily on human intervention and often fail to provide real-time threat detection and immediate response. This paper presents an AI-driven intelligent autonomous surveillance and women safety system that integrates robotic patrolling with a personal emergency protection device. The proposed system consists of an autonomous patrol robot equipped with real-time video streaming, AI-based object detection using MobileNet SSD, line-following navigation, and metal detection for threat identification. In parallel, a compact women's safety device is designed using GPS and GSM modules to transmit emergency alerts with live location information and provide physical self-defense during critical situations. Experimental results demonstrate effective autonomous navigation, accurate object detection, low-latency video streaming, and rapid emergency alert delivery. The integrated approach significantly reduces human dependency, enhances situational awareness, and improves response time. The proposed system is suitable for deployment in campuses, residential areas, public spaces, and other security-sensitive environments.

Keywords: Autonomous Surveillance, Artificial Intelligence, Object Detection, Women Safety, Raspberry Pi, Embedded Systems.

1. INTRODUCTION

Rapid urbanization and the growing complexity of modern cities have led to an increased demand for efficient security and safety systems. Traditional surveillance mechanisms such as Closed-Circuit Television (CCTV) cameras and manual security patrolling are widely used to monitor public and private spaces. However, these systems are largely passive in nature and depend heavily on continuous human supervision. As a result, delayed threat detection, limited coverage, human fatigue, and slow response times remain major challenges in conventional security infrastructures. Recent advancements in Artificial Intelligence (AI), computer vision, robotics, and embedded systems have enabled the development of intelligent surveillance solutions capable of real-time monitoring and autonomous decision-making. AI-based object detection techniques can analyze live video streams to identify suspicious activities, unauthorized individuals, or hazardous objects with higher accuracy and speed. Autonomous mobile robots further enhance surveillance by providing dynamic area coverage, overcoming the limitations of fixed camera installations. In parallel, personal safety—especially women's safety—has become a critical concern due to the rise in incidents such as harassment, stalking, and assault. Existing safety solutions primarily rely on mobile applications that send emergency alerts or share live locations. These solutions often fail during critical situations due to dependency on smartphones, internet connectivity, or the user's ability to operate the device under stress. Moreover, most systems lack immediate physical protection mechanisms, leaving victims vulnerable until help arrives.

To address these limitations, this paper proposes an **AI-driven intelligent autonomous surveillance and women safety system** that integrates public-level surveillance with individual-level emergency protection. The proposed system consists of an autonomous patrol robot capable of real-time video streaming, AI-based object detection using MobileNet SSD, line-following navigation, and metal detection for threat identification. Additionally, a compact women's safety device is designed using GPS and GSM modules to transmit instant SOS alerts with live location details and provide physical self-defense during emergency situations. By combining autonomous robotic surveillance with a personal safety device, the proposed system minimizes human dependency, improves situational awareness, and ensures rapid response to potential threats. The integrated approach makes the system suitable for deployment in educational institutions, residential complexes, public spaces, industrial zones, and other security-sensitive environments.

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2. RELATED WORK

Recent research has shown significant progress in the development of intelligent surveillance systems and personal safety solutions using Artificial Intelligence, Internet of Things (IoT), and embedded technologies. Various studies have explored the use of autonomous robots for security patrolling to reduce human involvement and improve monitoring efficiency. IoT-based surveillance robots equipped with cameras and sensors have been proposed to perform automated patrolling in residential and commercial environments, providing live video feeds and basic motion detection capabilities. While these systems enhance coverage, most of them lack advanced intelligence for accurate threat identification and real-time decision-making. With the advancement of deep learning, computer vision-based surveillance systems have gained attention for their ability to detect and recognize objects, human activities, and abnormal behaviors. Convolutional Neural Network (CNN)–based models such as MobileNet SSD, YOLO, and Faster R-CNN have been widely used for real-time object detection in surveillance applications. These approaches offer improved accuracy and faster inference, making them suitable for deployment on resource-constrained devices like Raspberry Pi. However, many existing systems focus only on video analytics and rely on static cameras, limiting their coverage area and adaptability.

In the domain of personal safety, several women's safety systems have been developed using mobile applications, GPS tracking, and GSM-based alert mechanisms. These systems are designed to send emergency notifications and location details to predefined contacts during distress situations. Although effective in alert generation, most solutions depend on smartphones and internet connectivity, which may not always be reliable in critical conditions. Additionally, the majority of existing safety devices lack immediate physical self-defense features. From the literature, it is observed that surveillance systems and personal safety solutions are generally developed as independent systems addressing specific aspects of security. There is limited research focusing on the integration of autonomous surveillance with personal emergency protection into a unified framework. This gap highlights the need for a combined approach that offers proactive area surveillance along with reactive individual safety support. The proposed system aims to address this research gap by integrating AI-driven autonomous robotic surveillance with a standalone women's safety device to enhance overall security effectiveness.

3. BLOCK DIAGRAM AND SYSTEM ARCHITECTURE

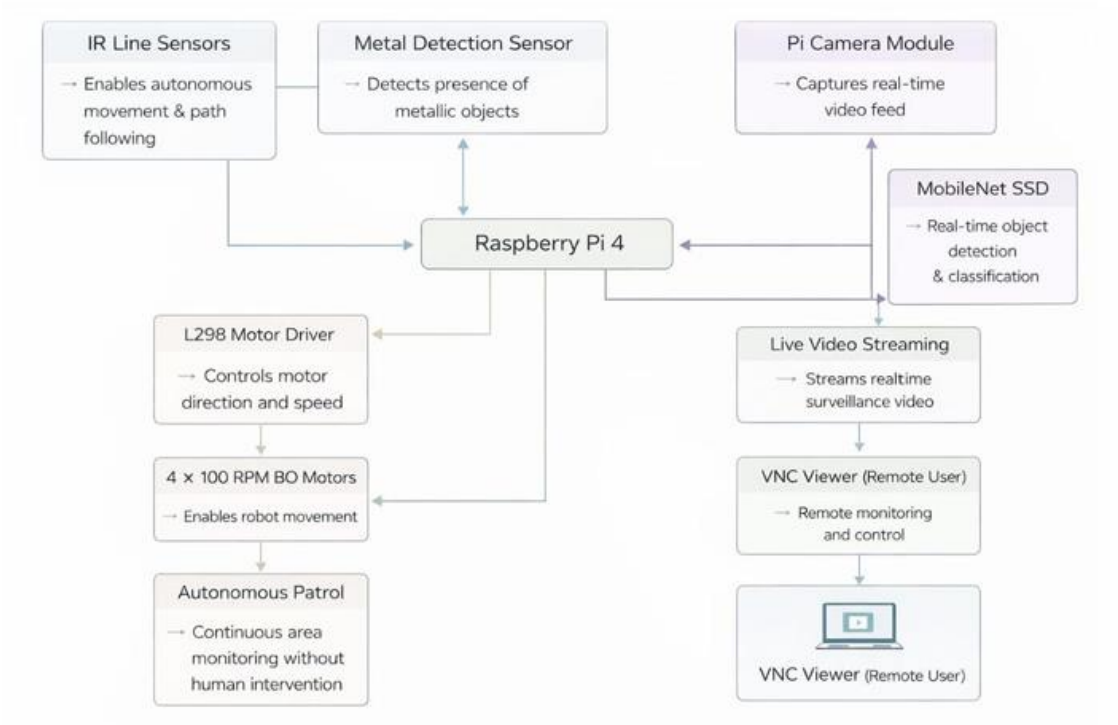

Fig. 1. Block Diagram of AI-Based Surveillance Robot

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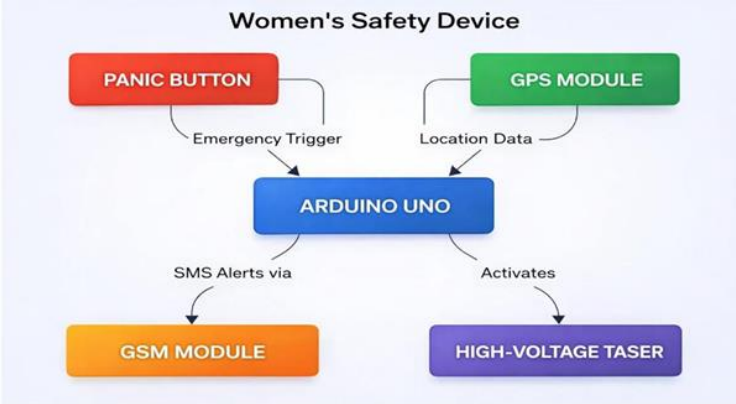

Fig. 2. Block Diagram of Women Safety Device

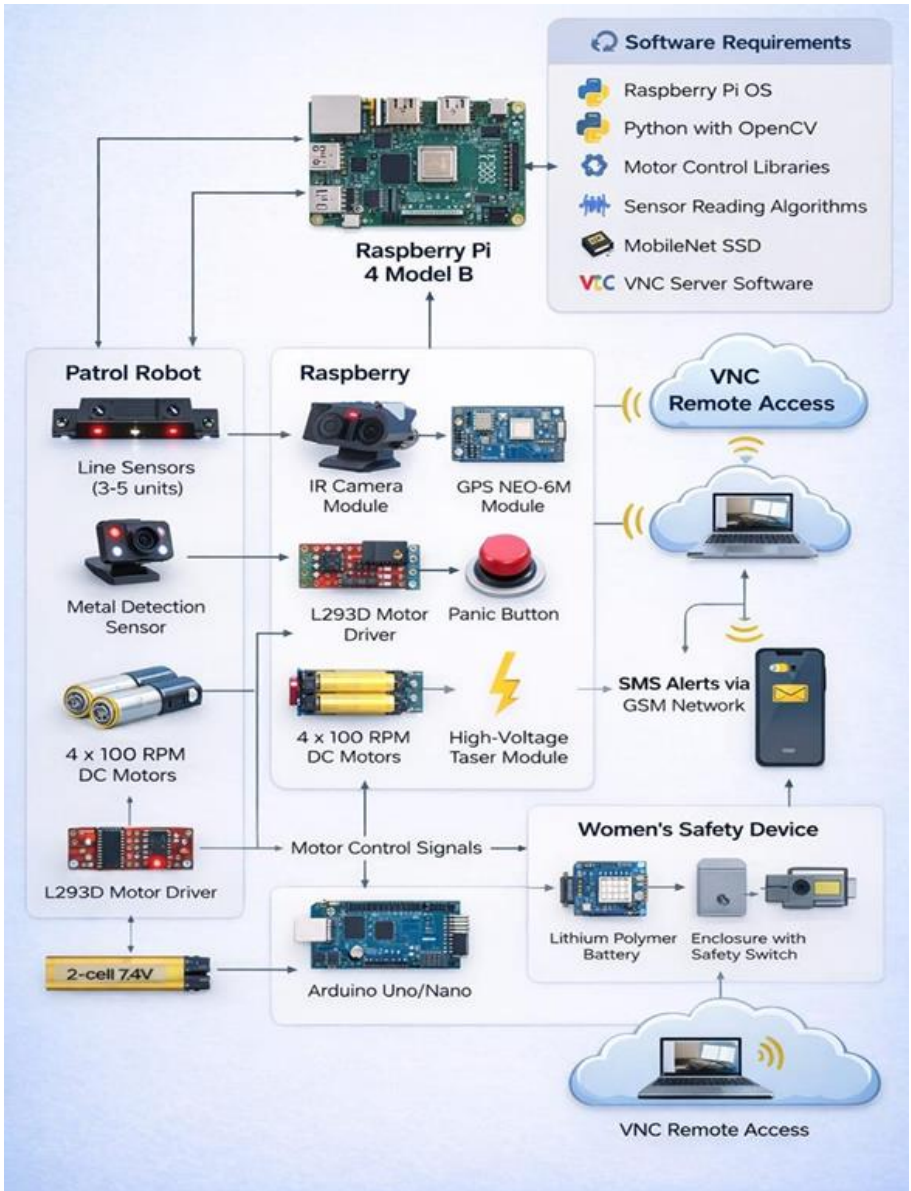

Fig. 3. System Architecture Of AI-Driven Intelligent Autonomous Surveillance Detection System

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4. PROPOSED SYSTEM

The proposed system is an integrated dual-level security solution designed to enhance public surveillance and personal safety through the use of Artificial Intelligence, robotics, and embedded systems. The system combines an autonomous surveillance robot for area-level monitoring with a compact women's safety device for individual-level emergency protection. By integrating both components into a unified framework, the system addresses the limitations of traditional security mechanisms that rely heavily on human intervention and delayed response. The autonomous surveillance robot is developed using a Raspberry Pi as the central processing unit. It is equipped with a camera module for real-time video streaming and AI-based object detection using the MobileNet SSD model. The robot performs autonomous patrolling by following predefined paths using IR-based line-following sensors, enabling systematic coverage of the surveillance area. In addition, a metal detection sensor is integrated to identify metallic objects that may indicate potential threats such as concealed weapons or hazardous materials. Live video streaming allows remote monitoring, while AI-based detection enhances situational awareness by identifying humans and suspicious objects in real time.

The women's safety device is designed as a standalone, portable system using an Arduino microcontroller. It integrates a GPS module to acquire real-time location coordinates and a GSM module to transmit emergency SOS messages to predefined contacts. A panic button is provided for quick activation during emergency situations. To enhance personal protection, the device also includes a controlled self-defense mechanism that can be activated when required. Unlike mobile application–based solutions, this device does not depend on internet connectivity or smartphones, making it more reliable during critical conditions. The integration of these two subsystems creates a comprehensive security architecture that provides proactive surveillance and reactive emergency response. While the patrol robot continuously monitors the environment, the women's safety device ensures immediate assistance at the individual level. This combined approach reduces response time, minimizes human dependency, and improves overall security effectiveness. The proposed system is suitable for deployment in educational institutions, residential complexes, public spaces, industrial areas, and other security-sensitive environments.

5. METHODOLOGY

The methodology of the proposed system focuses on the design and implementation of an AI-driven autonomous surveillance robot and a women's safety device, followed by their integration into a unified security framework. The development process emphasizes autonomous operation, real-time monitoring, and rapid emergency response with minimal human intervention.

1) A. Autonomous Surveillance Robot

The autonomous surveillance robot is built using a Raspberry Pi as the primary processing unit. The robot navigates through predefined routes using IR-based line-following sensors, ensuring consistent and structured patrolling. A camera module connected to the Raspberry Pi captures live video, which is streamed in real time to a remote monitoring system. The captured video frames are processed using the MobileNet SSD deep learning model to perform real-time object detection. This enables the identification of humans, vehicles, and other relevant objects during surveillance.

A metal detection sensor is integrated into the robot to identify the presence of metallic objects on the ground. When a metallic object is detected, the system generates an alert, indicating a potential threat. The robot's movement is controlled using a motor driver circuit that enables smooth forward, backward, and turning operations. The combination of autonomous navigation, AI-based object detection, and metal sensing enhances the robot's ability to monitor environments effectively without constant human supervision.

2) B. Women's Safety Device

The women's safety device is developed using an Arduino microcontroller and is designed to provide immediate assistance during emergency situations. A panic button is used as the primary trigger for the system. When activated, the device retrieves the user's real-time location using a GPS module and transmits an SOS alert containing the location coordinates through a GSM module to predefined emergency contacts.To enhance personal protection, the device incorporates a controlled self-defense mechanism that can be activated during critical situations. Safety measures are implemented to prevent accidental activation. The device operates independently of smartphones and internet connectivity, ensuring reliability even in areas with limited network access.

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3) C. System Integration

After individual module development, both subsystems are integrated to function as a coordinated dual-level security system. The surveillance robot provides continuous environmental monitoring, while the women's safety device offers instant personal emergency response. This integrated methodology ensures proactive threat detection at the area level and reactive protection at the individual level, significantly improving overall security effectiveness.

6. RESULT AND PERFORMANCE ANALYSIS

The proposed AI-driven autonomous surveillance and women safety system was evaluated under real-time operating conditions to assess its performance, reliability, and effectiveness. The evaluation focused on autonomous navigation, object detection accuracy, live video streaming quality, emergency alert response, and overall system integration. The autonomous surveillance robot successfully performed line-following navigation using IR sensors, maintaining stable movement along predefined paths with minimal deviation. Live video streaming from the Raspberry Pi camera was continuous and stable, enabling effective remote monitoring with low latency. The AI-based object detection using the MobileNet SSD model accurately identified humans and surrounding objects in real time. The detection performance was effective in well-lit environments and slightly reduced under low-light conditions, which is a known limitation of vision-based systems.

The metal detection module responded promptly upon detecting metallic objects, generating alerts that indicate potential threats. This feature enhances the applicability of the system in sensitive and high-risk environments. The integration of autonomous navigation, object detection, and metal sensing demonstrates the capability of the robot to perform intelligent surveillance without constant human supervision. The women's safety device showed reliable performance during testing. When the panic button was activated, the device successfully retrieved real-time GPS coordinates and transmitted SOS alert messages through the GSM module to predefined contacts. The alert delivery time was observed to be within a few seconds, depending on network availability. The self-defense mechanism was activated only during emergency conditions, ensuring controlled and safe operation.

Overall, the results confirm that the integrated system effectively combines proactive surveillance with reactive personal safety support. Compared to traditional security systems that rely on fixed cameras and manual intervention, the proposed solution offers improved coverage, faster response time, and reduced human dependency. The experimental outcomes validate the feasibility of deploying the system in campuses, residential areas, public spaces, and other security-sensitive environments.

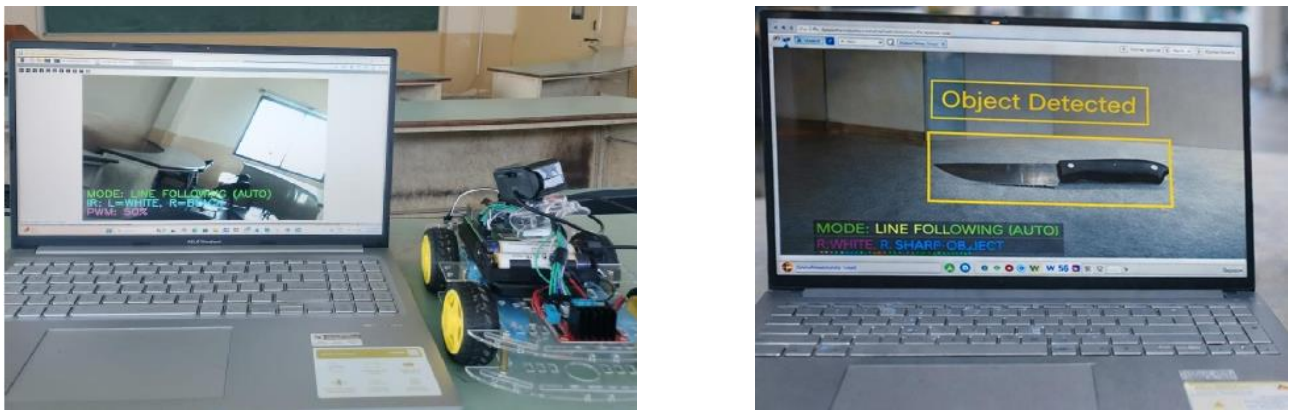

Fig. 4. Real-Time Object Detection Output Using MobileNet SSD on COCO Dataset and Live Video Streaming from Raspberry Pi Camera via VNC Viewer

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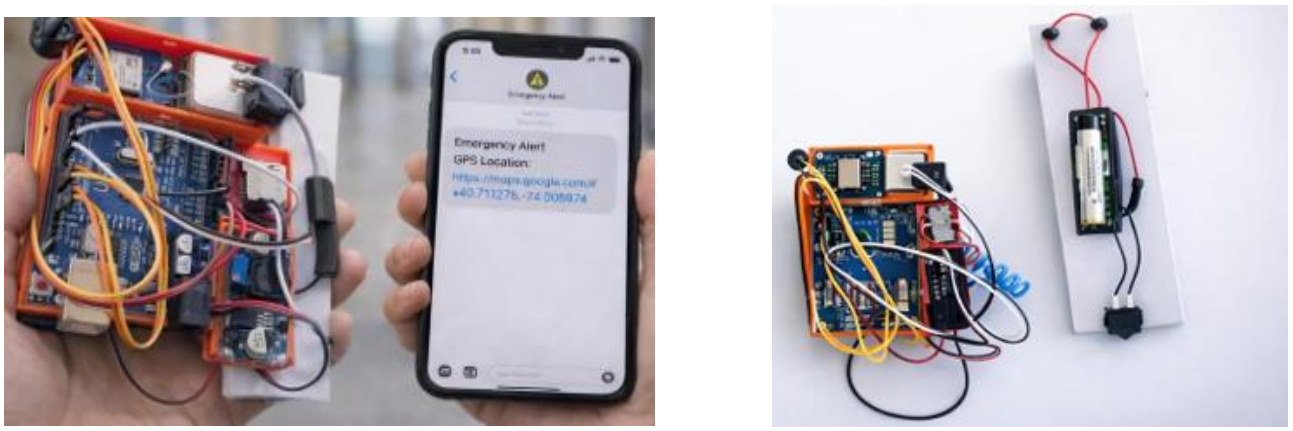

Fig. 5. Women's Safety Device Output Showing Panic Button Activation and SMS Alert with GPS Location and Self-Defense (Taser) Module Activation During Emergency Conditions

7. CONCLUSION AND FUTURE SCOPE

This paper presented an AI-driven intelligent autonomous surveillance and women safety system that integrates robotic patrolling with a personal emergency protection device to address modern security challenges. The autonomous surveillance robot demonstrated the ability to monitor environments continuously through real-time video streaming, AI-based object detection, and metal sensing, reducing dependency on manual security patrolling. Simultaneously, the women's safety device provided immediate emergency assistance by transmitting SOS alerts with live GPS location details and offering a controlled self-defense mechanism during critical situations.

The proposed system bridges the gap between public-level surveillance and individual-level safety by combining proactive environmental monitoring with reactive personal protection in a unified framework. Experimental observations confirmed reliable autonomous navigation, effective object detection, rapid alert transmission, and overall system stability. The integrated approach improves situational awareness, minimizes response time, and enhances security effectiveness compared to conventional surveillance and safety solutions.

Despite its effectiveness, the system has certain limitations. Object detection performance may vary under low-light conditions, and GSM-based alert delivery depends on network availability. Additionally, the patrol robot is currently restricted to predefined routes and does not perform dynamic path planning.

Future enhancements can focus on incorporating advanced navigation techniques such as obstacle avoidance and SLAM-based path planning, deploying more efficient deep learning models for improved detection accuracy, and enabling cloud-based storage for surveillance data. Further integration with IoT platforms and mobile applications can enhance real-time monitoring and scalability, making the system more adaptable for smart city and large-scale security deployments.

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