

# IoT Based Smart Multi Application Surveillance Robot

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**Abstract**— The increasing demand for intelligent, autonomous, and remotely accessible surveillance systems has led to the development of multi-functional robotic platforms using Internet of Things (IoT) technologies. This project presents the design and implementation of an IoT- Based Smart Multi-Application Surveillance Robot capable of performing real-time monitoring, hazard detection, and remote control through a wireless network. The proposed system is built around an ESP32 microcontroller, which acts as the central processing and communication unit, integrating sensing, actuation, and IoT connectivity. The robot is equipped with multiple sensors, including a gas sensor for detecting hazardous gas leaks, a flame sensor for fire detection, a Doppler sensor for motion and intrusion sensing, and a metal sensor for identifying metallic objects, making it suitable for defense, industrial, and security applications. A night vision camera enables visual surveillance in low-light and nighttime environments. Sensor data are continuously processed by the ESP32 and displayed locally on a 16×2 LCD, while critical alerts are communicated remotely using the Blynk IoT platform over Wi-Fi. Mobility is achieved using DC motors controlled through a motor driver, allowing precise movement of the robot's left and right wheels. In emergency or abnormal conditions, an onboard buzzer provides immediate audible alerts. The system is powered by a battery supply, ensuring portability and uninterrupted operation. Overall, the proposed surveillance robot offers a low-cost, scalable, and versatile solution for smart monitoring in military zones, disaster-prone areas, industrial sites, and restricted environments, enhancing safety through real-time sensing and IoT-enabled remote supervision

**Keywords**— *IoT, Surveillance Robot, ESP32, Smart Monitoring, Multi-Application System, Gas Sensor, Flame Sensor, Doppler Motion Sensor, Metal Detector, Night Vision Camera, Blynk IoT, Remote Monitoring etc.,*

## I. INTRODUCTION

The rapid advancement of Internet of Things (IoT) and embedded systems has significantly transformed modern military and surveillance operations. Traditional military reconnaissance and bomb disposal missions involve high risk to human life due to hostile environments, unexploded ordnance, and limited visibility. To overcome these

challenges, researchers have increasingly focused on developing IoT-enabled robotic systems capable of performing surveillance, monitoring, and explosive handling tasks remotely. Recent studies have demonstrated the effectiveness of IoT-based robotic platforms in military applications such as surveillance, border monitoring, and object detection. Sirisha Devi et al. [1] proposed an IoT-based military robot capable of real-time monitoring and wireless control, improving battlefield awareness. Similarly, Arjun et al. [3] developed a multifunctional robot that integrates sensors and wireless communication for military reconnaissance. Ravikiran et al. [4] emphasized the importance of smart surveillance robots using IoT for real-time video transmission and obstacle detection. With the advancement of sensor fusion and intelligent control, modern robotic systems are now capable of detecting metals, capturing live video, and transmitting environmental data. However, most existing systems lack an effective mechanism for safe bomb handling and disposal. Recent studies have highlighted the importance of robotic arms for explosive handling to minimize human involvement in hazardous operations [13–15]. The integration of robotic arms with IoT-based mobile platforms offers a promising solution for real-time bomb detection, identification, and disposal. Therefore, this project focuses on developing a multi-functional IoT-based military robot integrated with a robotic arm for bomb disposal, real-time surveillance, and wireless control. The system aims to enhance safety, operational efficiency, and situational awareness in defense and security applications.

The remainder of this paper is organized as follows.

Section 2 presents a comprehensive literature survey discussing existing IoT-based military robots, surveillance systems, and bomb detection technologies, highlighting their methodologies and limitations. Section 3 describes the proposed multi-functional robotic system in detail, including hardware architecture, working principle, and the integration of the robotic arm for bomb disposal. Section 4 discusses the experimental results and performance analysis of the developed system in terms of functionality, reliability, and real-time operation. Finally, Section 5 concludes the paper with key findings and outlines the future scope of the proposed system for advanced defense and security applications.

**II. LITERATURE SURVEY**

Recent advancements in robotics and the Internet of Things (IoT) have significantly contributed to the development of intelligent systems for military and surveillance applications. In high-risk environments such as bomb detection, border surveillance, and reconnaissance missions, human involvement is highly dangerous. Hence, researchers have focused on designing autonomous and semi-autonomous robotic systems integrated with sensors, wireless communication, and real-time monitoring capabilities. Ch.S.N. Sirisha Devi et al. [1] proposed an advanced IoT-based robot designed for military operations such as surveillance and remote monitoring. The system sent real-time data to a control station via wireless connection and sensors. The robot enhanced situational awareness, but it lacked bomb-handling and object-manipulation capabilities, which are essential for military missions. Some researchers named M. T. and his team built a flying robot, or drone, to check on farms. It connects to the internet, saves a lot of battery, and lets people watch the farm from far away. The only catch is that it only flies high up. It can't deal with dangers on the ground, like bombs. But it is really good at working on its own without wasting power.

In another project, Arjun B. and Dr. Suresh D. built an army robot. Their robot also uses the internet to spot things blocking its path and to keep an eye on an area. By allowing live video transmission and remote navigation, the technique increased combat awareness. However, the utilization of the model in explosive handling circumstances was limited because it lacked an operational robotic arm and a bomb disposal system. An IoT-based smart surveillance robot for use in military environments was developed by K. Ravikiran et al. [4]. The robot was fitted with sensors and wireless communication modules to monitor its environment and detect attackers. Although the system was effective for monitoring, it lacks independent decision-making and physical item handling features like grabbing or disposing units. Govindaraj and companions. An Internet of Things-based patient monitoring system that forecast health using deep learning was introduced by Govindaraj et al. [5]. A group of individuals created a system designed to monitor the health of those who were unwell. It uses smart computer programs and the internet to guess how a patient's health will do. They found out it's really good at grabbing information the exact second it happens and putting it all together online. Even though this was made for hospitals, the exact same tech could be used for army robots. For example, it could check if a robot is working right, or it could keep an eye on how healthy the soldiers are. Abdul Qadir et al. [6] created a military robot with Internet of Things capabilities that can be used for surveillance and remote navigation. They focused on obstacle recognition and real-time video streaming. However, the system lacked intelligent automation and bomb-handling capabilities and was mostly dependent on human control. Kotwal et al. [7] Key characteristics including wireless control, camera integration, and multi-sensor fusion were highlighted in a thorough overview of IoT-based multifunctional military robots. The report also identified automated threat-handling mechanisms and small robotic arms as research gaps in several existing systems. Senthilkumar et al. [8] and

Shobana et al. [9] The study determined communication and signal processing methods that were designed to allow successful information transmission in embedded devices. In robotic systems developed for security forces and control, how they improve processing speed and communication reliability. [10] and B. Venkatesan et al. [11] created Internet of Things (IoT)- based military vehicle robots with remote operation and real-time video streaming; while these systems enhanced combat visibility, they lacked the cognitive manipulation tools needed for bomb disposal duties. Vaibhavi Wanjari and Chandrashekar Kamargaonkar [12] The research suggested using IoT and integration of sensors to create an autonomous robot for wartime inspection. The robot required mechanical actuation controls for controlling explosives, although demonstrating improved decision-making abilities. Recent studies by Smith and Johnson [13], Patel et al. [14], and Lee et al. [15] emphasized the importance of AI-based bomb detection, sensor fusion, and robotic manipulation systems. These investigations highlighted the need for vision-based detection systems, autonomous robotic arms, and real-time response mechanisms to guarantee the safe detection and disposal of explosives in hazardous locations.

TABLE I. SUMMARY OF REVIEWED LITERATURE

Ref	Author & Year	Contribution	Limitation
[1]	Sirisha Devi et al., 2019	IoT-based military robot for surveillance and monitoring	No bomb disposal mechanism
[2]	M. T et al., 2023	Energy-efficient flying robots for monitoring	Limited to aerial monitoring
[3]	Arjun B et al., 2019	Multi-functional military robot using IoT	No robotic arm integration
[4]	Ravikiran et al., 2023	Smart surveillance robot using IoT	Only monitoring, no handling
[5]	Govindaraj et al., 2023	IoT-based health monitoring using AI	Medical-focused, not defense
[6]	Abdul Qadir et al., 2023	IoT-based military robot	Lacks automation in disposal
[7]	Kotwal et al., 2021	Survey on multifunctional robots	No practical implementation
[8]	Senthilkumar et al., 2023	Efficient signal processing design	Not related to robotics
[9]	Shobana et al., 2023	Wireless handoff optimization	Not applied to robotics
[10]	Kurlekarr et al., 2021	Military vehicle robot	No arm or bomb handling
[11]	Venkatesan et al., 2019	Fighter robots using IoT	Limited sensing capabilities
[12]	Wanjari et al., 2020	Cognitive military robot	High complexity, cost
[13]	Smith & Johnson, 2024	Bomb detection robotics review	No real-time prototype
[14]	Patel et al., 2023	AI-based bomb disposal	High computational demand
[15]	Lee et al., 2023	Sensor fusion for bomb detection	No robotic manipulation

**RESEARCH GAP**

A comprehensive analysis of the body of research on IoT-based military robots, surveillance systems, and defense

focused robotic platforms identifies a number of important research gaps. The majority of existing systems place little emphasis on active threat management, especially when it comes to bomb detection and disposal, and instead concentrate mostly on surveillance, monitoring, or basic mobility. Though some studies use cameras and sensors for remote surveillance, they need the automated intervention capabilities necessary to conduct real-time military and security operations. Also, many of the systems in existence today are single-purpose robots that can only perform specific tasks like surveillance, environmental monitoring, or communication. Few methods, such as robotic arm-based disposal, obstacle detection, metal detection, and live video communication, combine many elements onto a single platform. Moreover, most of these systems mainly depend on manual control without intelligent aid, which increases response time and placing human operators at risk while handling hazardous objects or disposing of bombs. The absence of dependable manipulation mechanisms has been noted as another significant drawback. While many robots are able to identify dangers, they frequently lack an articulated robotic arm that can safely handle, pick up, or dispose of explosives. Because of this restriction, they are less useful in actual warfare situations where it is essential to engage directly with suspicious objects. Furthermore, the majority of systems lack real-time wireless monitoring and actuation integration, which restricts operational flexibility in high-risk or combat situations. Additionally, cost-effective and compact designs appropriate for real-world implementation have received little attention in prior research. Scalability and field implementation are impeded by the usage of costly sensors, intricate system architectures, and power-inefficient designs. Additionally, the incorporation of low-power controllers and effective motor control with IoT-based monitoring has not been sufficiently assessed.

Therefore, creating a small, inexpensive, Internet of Things-enabled multipurpose robotic system that combines these essential attributes is a major research gap:

- Real-time surveillance
- Wireless control and monitoring
- Metal and threat detection
- Robotic arm-based bomb disposal
- Reliable mobility in hazardous environments
- Maintaining efficient mobility in dangerous situations is essential.

By creating a multifunctional military robot with an intelligent robotic arm for bomb disposal, IoT-based monitoring, and real-time control, the proposed study aims to overcome these restrictions. In defense applications, this strategy seeks to raise overall mission effectiveness, improve operational efficiency, and improve safety.

### III. PROPOSED METHOD

The development of an IoT-Based Smart Multi-Application Surveillance Robot designed to strengthen safety and monitoring in hazardous and restricted environments is the primary objective of the proposed strategy. The ESP32 microcontroller acts as the system's central control unit, processing wireless connection, robot movement, and

sensor data. To detect several risks at once, multiple sensors have been integrated, such as gas, flame, Doppler motion, and metal sensors. Even in low light as well as night, real-time visual surveillance is made possible by a night vision camera.

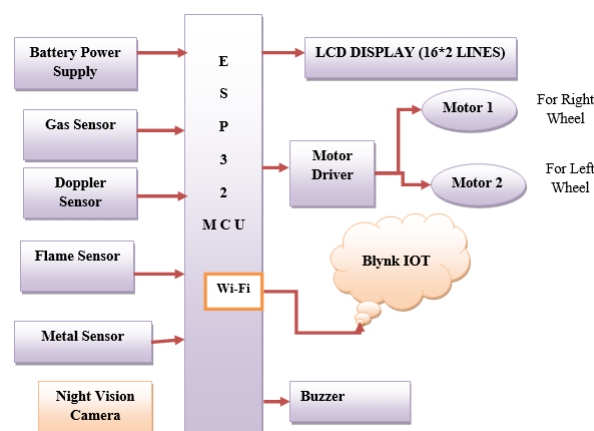


Fig. 1. System Block diagram

Users are able to get real-time sensor data and alarms on a mobile application by controlling and monitoring the robot remote through an IoT platform through Wi-Fi. Sensor data is shown on an LCD, and a buzzer is utilized to transmit local alerts. All things considered, the proposed method decreases human risk, improves up reaction times, and provides a reliable and efficient solution for modern surveillance applications. The system architecture shown in fig.1.

#### A. Methodology

##### 1) System Initialization

The ESP32 microcontroller starts the motor driver, LCD, buzzer, camera module, and all attached sensors when power is applied. The system interfaces to the IoT platform through Wi-Fi and ensures if the sensors are ready (Blynk).

##### 2) Robot Movement Control

The mobile app provides commands that control the movement of the robot. For range observation, the ESP32 processes these commands and sends the motor driver to move the DC motors forward, backward, left, or right.

##### 3) Gas Detection Methodology

The gas sensor keeps monitoring out for dangerous or flammable gases in the surrounding air. The ESP32 analyzes the sensor output and compares it to a set threshold. The system rings the buzzer and alerts the IoT platform if the gas concentration in the safe limit.

##### 4) Flame Detection Methodology

The ESP32 continuously analyzes the sensor output to send an early fire warning. It uses a buzzer and a mobile application to immediately produce warnings when it senses a flame.

### 5) Doppler Motion Detection Methodology

Within the monitored area, the Doppler motion sensor detects motion or entry. The ESP32 notifies the user of possible illegal activity when motion is identified by processing the signal and updating the IoT dashboard.

### 6) Metal Detection Methodology

To find metallic things like guns or mines, the metal sensor looks about. When such objects are found, the ESP32 supports military and security applications by recording the occurrence and notifying the user via the Internet of Things platform.

### 7) Night Vision Camera Surveillance

Even in low light or darkness, the night vision camera's real-time video of the surroundings enables efficient surveillance. The user can independently evaluate and comprehend the surroundings thanks to this live broadcast.

### 8) Alert and Display Methodology

A 16x2 LCD is used for local monitoring, showing data from sensors and device status. When an emergency arises, the buzzer sends an immediate alert.

### 9) IoT-Based Remote Monitoring

Wi-Fi is used for transferring all sensor data and warnings to the Blynk IoT platform. This enables the user to make a mobile device to remotely control the robot, monitor real-time data, and get notifications.

## B. Algorithm

### Algorithm 1: IoT-Based Smart Multi-Application Surveillance Robot

Step 1: Start the system.

Step 2: Set up the ESP32 microcontroller, LCD, buzzer, motor driver, camera, and sensors (gas, flame, Doppler motion, and metal).

Step 3: Establish contact with the Blynk IoT platform by connecting the ESP32 to the Wi-Fi network.

Step 4: Expect the mobile application's movement instructions.

Step 5: Control robot movement (forward, backward, left, right) based on received commands.

Step 6: Read the results from the gas sensor and compare them to a predetermined threshold. If gas level exceeds limit, activate buzzer and send alert to Blynk.

Step 7: Examine the results of the flame sensor. If a flame is found, transmit a fire alarm and turn on the buzzer.

Step 8: Monitor Doppler motion sensor.

- If motion is detected, send intrusion alert to Blynk.

Step 9: Monitor metal detector sensor.

- If metal is detected, send metal detection alert.

Step 10: Display sensor readings and system status on LCD.

Step 11: Transmit all sensor data to the IoT platform for real-time monitoring.

Step 12: Repeat Steps 4 to 11 continuously for real-time surveillance.

Step 13: Stop the system when power is turned off

## C. Implementation

The ESP32 microcontroller initializes all of the related sensors, motor driver, LCD, buzzer, and communication modules after the system turns on. This is the first step in the installation of the suggested IoT-based smart multi-application surveillance robot. Once startup is completed, the ESP32 connects to the IoT platform through Wi-Fi to enable remote monitoring and control. The motor driver then uses user input to control the DC motors to get the robot in the right direction while the robot waits for movement directions from the mobile application. The ESP32 regularly reads data from the metal, gas, flame, and Doppler motion sensors when it is in operation. To determine whether any dangerous conditions exist, these sensor values are analyzed in real time. If a danger such as gas leakage, fire, motion intrusion, or metal detection is identified, the system immediately activates the buzzer and displays the alert information on the LCD. At the same time, sensor data and alert notifications are transmitted to the mobile application through the IoT platform, enabling remote monitoring

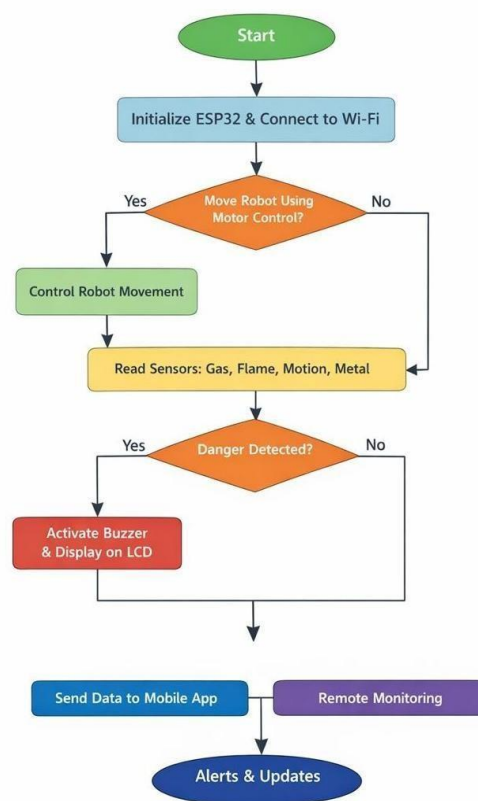


Fig. 1. Implementation of proposed method

## IV. RESULTS AND DISCUSSION

### 1) Hardware Setup

The performance of the suggested IoT-based smart multi-application surveillance robot was assessed in a range of operational and environmental settings. The effectiveness of IoT-based remote monitoring, sensor accuracy, reaction speed, and alarm

generation were all examined. The outcomes show that the system efficiently accomplishes the goals of hazard identification and real-time surveillance while operating dependably.

## 2) Sensor Performance Analysis

The performance of various sensors employed in the suggested system is displayed in Table II. Several test situations were used to examine response speed and detection accuracy.

TABLE II. SENSOR PERFORMANCE RESULTS

Sensor	Detection Accuracy (%)	Response Time (ms)
Gas Sensor	96	850
Flame Sensor	98	600
Doppler Motion Sensor	95	700
Metal Sensor	97	750

The flame sensor is very useful for early fire detection since it has the lowest response time and the best detection precision (98%). The gas sensor exhibits dependable performance with 96% accuracy; nevertheless, because to sensor warm-up characteristics, its response time is significantly longer. And also, Doppler motion and metal sensors have great accuracy, indicates it suitable for security and interference applications.

## 3) Detection Accuracy Comparison

The level of detection of each sensor is shown in Figure 3. Each sensor had an accuracy of over 95%. Flame and metal sensors function well. shows the ability to effectively recognize a number of risks. The graph displays reliable and consistent detection from every sensor. High accuracy increases reliability of the system overall and lowers false alarms.

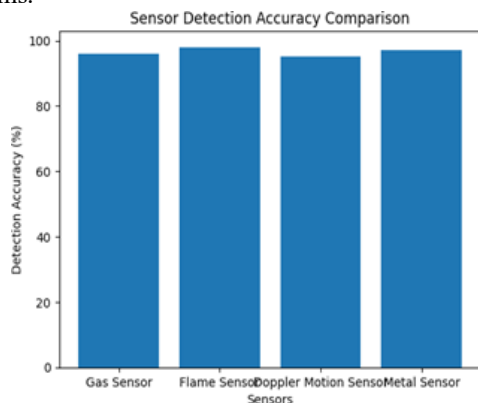


Fig. 2. Sensor Detection Accuracy Comparison

## 4) Response Time Analysis

The response times from various sensors are compared in Figure 4. The flame sensor is the fastest sensor. The gas sensor acts a bit more slowly. Every sensor reacts within the normal ranges. It's important to act quickly in an emergency. Because the proposed system responds in milliseconds, the IoT platform can quickly issue alerts and notify users.

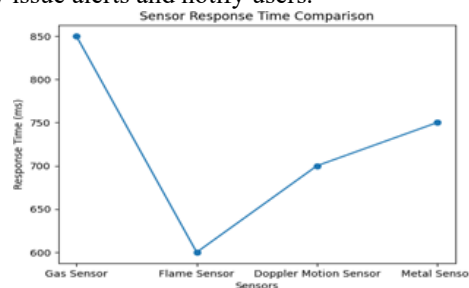


Fig. 4. Sensor Response Time Comparison

## 5) IoT Monitoring and Alert Performance

The Blynk was IoT platform interface allows real-time monitoring and instant alert messages. Sensor data was transmitted to the mobile application with very little delay, and in response to unusual situations such as motion, metal detection, gas leakage, or fire, warnings were created quickly. This IoT-based monitoring improves system usability and decreases the need for human presence in hazardous places by allowing users to remotely operate and monitor the robot.

## V. CONCLUSION AND FUTURE SCOPE

IoT-Based Smart Multi-Application Monitoring Robots provide an effective way to monitor hazardous and restricted areas without risking human life. The system's integration of many different sensors, a night vision camera, and Internet of Things connectivity allows real-time detection of gas leaks, fire, motion, and metal items. Reaction times become faster and overall safety is increased through instant notifications and remote monitoring. The recommended solution is suitable for industrial, security, and disaster management applications and is cost-effective and reliable. GPS for real-time position tracking and artificial intelligence for autonomous threat evaluations are two possibilities to extend the proposed method. implementation of obstacle avoidance and autonomous navigation. logging and analysing data utilizing cloud storage. Strong camera integration for item and face identification

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