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IoT-Driven Multi-Functional Combat Support Robot for Real-Time Military Operations

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ABSTRACT

In today's rapidly evolving defense landscape, ensuring the safety of military personnel while enhancing operational efficiency has become a top priority. The integration of robotics and the Internet of Things (IoT) into military systems has opened new frontiers for developing intelligent, multifunctional robotic systems capable of performing high-risk tasks. This project proposes the design and development of a Multi-Functional Military Robot empowered with IoT capabilities, capable of performing multiple surveillance, environmental monitoring, and safety functions in real-time. The robot is equipped with various sensors and modules to detect hazardous gases, monitor temperature and humidity, detect obstacles, and provide real-time feedback to a remote operator.

At the heart of the system lies the ESP8266 microcontroller, which serves as the communication backbone by interfacing all sensors and modules while enabling cloud-based monitoring and control. The DHT11 sensor continuously monitors temperature and humidity conditions in the field, providing critical environmental data which may affect soldier operations or indicate biological threats. The MQ-7 gas sensor plays a vital role in detecting toxic gases such as carbon monoxide (CO), making the robot valuable for chemical or smoke-laden environments such as bomb sites or enemy bunkers. The IR sensors mounted on the robot serve as obstacle detectors, enabling autonomous or semi-autonomous navigation, and minimizing the risk of collision in unfamiliar terrains.

INTRODUCTION

The advancement of modern warfare and military technologies has seen a major shift towards automation, remote surveillance, and intelligent decision-making to minimize human casualties and enhance efficiency. In such a rapidly changing defense environment, the integration of robotics and IoT (Internet of Things) technologies into military systems has emerged as a revolutionary development. Robotics can now be deployed in high-risk areas, reducing the physical burden and danger for soldiers. One such innovation is the Multi-Functional Military Robot integrated with IoT, developed as a low-cost, modular, and smart system capable of performing multiple critical tasks in real-time, remotely and

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autonomously. This project represents an effort to address the challenges of modern battlefield environments, where human presence is either risky or practically impossible. The primary objective of this multi-functional robot is to assist in surveillance, environmental monitoring, hazard detection, and frontline reconnaissance using a combination of embedded systems and IoT capabilities. With the help of microcontrollers, sensors, and wireless communication, the robot becomes an intelligent agent that can navigate, monitor, detect, and report without the constant need for manual intervention. The integration of components such as HC-05 Bluetooth module, ESP8266 Wi-Fi module, DHT11 temperature and humidity sensor, MQ-7 gas sensor, IR obstacle sensors, buzzer, and a mechanical robotic chassis forms the core of the system, making it both powerful and versatile.

The DHT11 sensor allows the robot to sense ambient temperature and humidity in operational areas, which could affect the health of soldiers or signify biological threats. The MQ-7 sensor is designed to detect dangerous gases like carbon monoxide (CO), which could be present due to gas leaks, fire outbreaks, or chemical warfare. Real-time detection of these parameters is critical for ensuring safety during search-and-rescue missions, tunnel explorations, or during operations in enemy territory. Additionally, the robot is equipped with IR sensors to detect obstacles in its path, allowing semi-autonomous movement in complex terrain. This makes the robot suitable for environments like forests, war zones, disaster-struck regions, or even bunkers.

EXISTING SYSTEM

The existing systems in military surveillance and hazardous environment detection have traditionally relied on manual patrolling, human intervention, and basic surveillance equipment such as CCTV cameras, walkie-talkies, and thermal scanners. While some advancements have introduced semi-automated drones and ground surveillance units, most of the existing military-grade robots lack multifunctionality, affordability, and real-time environmental sensing. Many systems are designed for single-purpose use, such as bomb defusal or video surveillance, and lack integration with environmental sensors or wireless IoT platforms. Moreover, the existing robotic solutions are often bulky, expensive, and require specialized operators to function. In border areas and conflict zones, ground soldiers often face dangers like landmines, harmful gases, sudden temperature drops, or intruder threats without prior warning. These risks continue due to limited use of intelligent robotics on the field.

Furthermore, current surveillance mechanisms often operate with latency and limited mobility. Traditional robots used for remote operations are not equipped with modular environmental sensors like DHT11 for temperature/humidity, or MQ-series gas sensors for chemical hazard detection. Communication in many of these systems is restricted to local RF or line-of-sight remote controls, which limits operational range. There's also a lack of integration with cloud-

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based platforms where real-time data can be logged, monitored, and acted upon from remote locations such as a central command center. In scenarios involving hazardous gas leaks or fires in underground tunnels or enemy bunkers, there are no mechanisms in place in the existing robots to alert personnel of the imminent threats using buzzer alarms or mobile notifications. As a result, soldiers are exposed to harmful environments without adequate situational awareness.

DISADVANTAGES

- Lack of Real-Time Monitoring
- Single-Function Capability
- No Environmental Sensing
- Short Communication Range
- No IoT Integration
- High Cost and Maintenance
- Manual Operation Dependency
- Inflexible Design
- Limited Sensor Integration
- No Emergency Alert System

PROPOSED SYSTEM

The proposed system introduces a Multi-Functional Military Robot integrated with IoT, specifically designed to operate in high-risk environments where human presence is either unsafe or impractical. This robot aims to overcome the limitations of existing systems by incorporating a modular set of features that include environmental sensing, obstacle detection, real-time alerts, wireless communication, and mobile-based control. At the heart of the system is the ESP8266 NodeMCU, which acts as the central processing and communication unit, enabling the robot to interact with sensors and transmit data to cloud platforms or mobile apps. This integration allows military personnel to monitor battlefield parameters remotely and act based on live data without direct exposure to danger. To provide situational awareness, the robot is equipped with a DHT11 sensor for temperature and humidity monitoring, helping detect unsafe climatic conditions or biological threats. Additionally, the MQ-7 sensor is used to identify the presence of harmful gases like carbon monoxide, which could originate from explosives, enemy attacks, or environmental hazards. These sensors continuously collect data and transmit it via the ESP8266 to IoT platforms such as Blynk or ThingSpeak, where it is visualized and stored for further analysis. This ensures the operator has real-time access to environmental readings during field operations. To improve navigation and operational autonomy, IR sensors are integrated to detect obstacles and prevent collisions, allowing the robot to move efficiently through narrow tunnels, rough terrains, or unknown areas without constant manual control.

The robot's movement can be controlled in two ways: locally via HC-05 Bluetooth module for short-range wireless control, and remotely through Wi-Fi using IoT dashboards. This dual-mode operation ensures uninterrupted performance in both connected and offline environments. For immediate alerts, a buzzer module is incorporated into the system that activates when a threshold condition is met (e.g., dangerous gas levels or extreme temperature), thus providing both local and remote notifications. The robot's mechanical design is built for rugged environments, with a mobile platform capable of carrying

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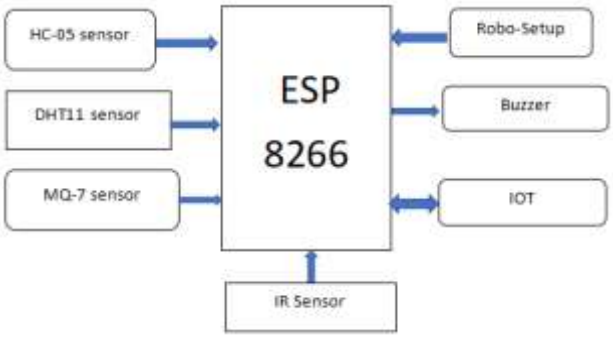
sensors and modules, making it suitable for battlefield deployment, border patrol, mine detection, or disaster rescue operations.

ADVANTAGES

- Real-Time Monitoring and Control
- Early Detection of Environmental Hazards
- Intrusion and Movement Detection
- Remote Operation to Minimize Risk
- Instant Alert Mechanism
- Lightweight and Mobile Robot Setup
- Cost-Efficient Deployment
- Data Logging for Analysis
- Flexibility and Scalability

BLOCK DIAGRAM



HARDWARE COMPONENTS

- DHT11 sensor
- MQ-7 sensor
- IR sensor
- Robo-Setup
- IOT
- Buzzer
- ESP8266

ESP8266

The ESP8266 is a compact and cost-effective Wi-Fi microcontroller module developed by Espressif Systems, widely used in IoT (Internet of Things) applications. It comes with an integrated TCP/IP protocol stack that allows any microcontroller to connect to a Wi-Fi network and make internet connections. The ESP8266 can operate both as a Wi-Fi client and as an access point, meaning it can connect to existing networks or create its own. Internally, it is powered by a 32-bit Tensilica L106 microprocessor and has built-in flash memory, RAM, and GPIO (General Purpose Input/Output) pins to connect various sensors and actuators. It supports programming through the Arduino IDE, MicroPython, or other development platforms, enabling developers to upload custom code easily. In operation, the ESP8266 reads data from connected sensors like DHT11 (temperature and humidity), MQ-7 (gas detection), or IR sensors, processes it, and transmits it over the internet using MQTT or HTTP protocols. For example, it can send real-time data to a cloud server or mobile app and can also receive control commands from remote users. It enables remote monitoring, alert triggering, and automation in embedded systems. Due to its low power consumption, built-in Wi-Fi, and versatile programming support, ESP8266 is ideal for applications such as military robots, home automation,

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industrial control, and environmental monitoring systems.

DHT11

The DHT11 is a widely used digital sensor that measures temperature and humidity. It contains a thermistor for sensing temperature and a capacitive humidity sensor to detect the moisture content in the air. The sensor operates on a single-wire digital interface, which means both data and clock signals are sent through the same pin, making it simple to connect with microcontrollers like Arduino, ESP8266, or Raspberry Pi. When powered (typically with 3.3V to 5V), the DHT11 samples the surrounding environment at regular intervals and outputs a calibrated digital signal. The data transmission begins when the microcontroller sends a start signal, and the DHT11 responds by sending a 40-bit data stream: 16 bits for humidity, 16 bits for temperature, and 8 bits for checksum validation. Though the DHT11 offers a temperature range of 0–50°C with an accuracy of ±2°C and humidity range of 20–90% RH with ±5% accuracy, it is best suited for basic applications where low cost and ease of use are more important than high precision. In military robotic systems, it helps monitor ambient environmental conditions, ensuring personnel safety by detecting heat or moisture anomalies in the field.

MQ7 GAS SENSOR

The MQ-7 is a semiconductor-based carbon monoxide (CO) gas sensor used in embedded systems to detect CO concentrations in the air. It operates using a tin dioxide (SnO_2) sensing element, which changes its electrical resistance in the presence of carbon monoxide. The sensor has a built-in heater coil that cycles between high and low temperatures to differentiate between gases and improve accuracy. During operation, the heater alternates between 1.5V (for sensing) and 5V (for heating). At high temperatures, it activates the sensor to burn off impurities, while at low temperatures, the sensor becomes sensitive to CO gas. As carbon monoxide levels increase, the resistance of the sensing element decreases, allowing more current to pass through. This change in resistance is converted into a voltage signal, which can be read by a microcontroller like Arduino or ESP8266. The MQ-7 sensor provides analog output proportional to the gas concentration and typically requires calibration in clean air for accurate readings. It can detect CO concentrations from 20 to 2000 ppm, making it ideal for safety-critical applications. In military or industrial robotic systems, MQ-7 is essential for early detection of toxic gases, protecting soldiers or operators from hazardous environments during operations such as rescue missions or surveillance in enclosed areas.

IR SENSOR

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An IR (Infrared) sensor is an electronic device that detects infrared radiation to sense the presence, motion, or distance of objects. It typically consists of an IR LED (transmitter) that emits infrared light and a photodiode or phototransistor (receiver) that detects the reflected light from nearby objects. When an object comes close to the sensor, the emitted IR light reflects off the surface of the object and is detected by the receiver, triggering a response. IR sensors operate on the principle of reflected infrared waves. The amount of reflected IR radiation received by the sensor determines whether an object is present and how far it is. The output is usually digital (HIGH or LOW), but some advanced versions offer analog output for distance measurement. In practical applications, IR sensors are used for obstacle detection, line-following robots, intrusion detection, and proximity sensing. In military robotic systems, they are essential for detecting enemy movement, avoiding obstacles, and navigating through dangerous or unknown terrains. IR sensors are lightweight, inexpensive, and energy-efficient, making them suitable for integration into compact and mobile robotic platforms.

BUZZER

A buzzer is an audio signaling device that produces sound when an electric voltage is applied. It typically consists of a piezoelectric element or electromechanical coil, which vibrates to create sound waves. When voltage is supplied, it causes the internal diaphragm or metal disc to oscillate, generating a tone or alarm. Buzzers are available in two main types: active (which produce sound on their own when powered) and passive (which require a frequency signal from a microcontroller to produce sound). In embedded systems and robotics, a buzzer is used as a notification or alert mechanism. It can be easily interfaced with microcontrollers like Arduino, ESP8266, or Raspberry Pi using a digital pin. A HIGH signal turns it ON, while a LOW signal turns it OFF. In military robotic applications, buzzers serve a critical role in instant audio alerts. They are used to warn soldiers or operators about gas leaks (from MQ-7), temperature anomalies (from DHT11), enemy intrusion (detected by IR sensors), or any other emergency conditions. The buzzer provides an immediate and noticeable response, making it a vital component for real-time safety and communication in the field.

MQTT

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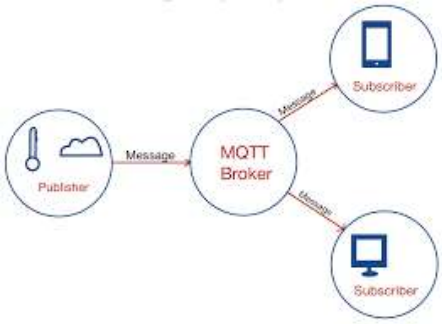

MQTT (Message Queuing Telemetry Transport) is a lightweight, publish-subscribe messaging protocol specifically designed for low-bandwidth, high-latency, or unreliable networks, making it ideal for IoT-based controlling and monitoring systems. It operates over the TCP/IP protocol and uses a central broker (such as Mosquitto or HiveMQ) to handle all message communication between devices (clients). In an MQTT-based system, devices are classified as either publishers, subscribers, or both. For example, a military robot equipped with an ESP8266 Wi-Fi module can act as a publisher by sending sensor data (e.g., gas level from MQ-7, temperature from DHT11, or movement detected by an IR sensor) to a topic on the broker. At the same time, a mobile application or web dashboard can subscribe to that topic and receive real-time data updates instantly. Similarly, MQTT also supports remote control. A smartphone or computer can publish commands (like moving forward, turning, or triggering a buzzer) to specific topics, and the robot subscribed to those topics will receive and execute the actions. This allows for bidirectional communication with very low latency. In military applications, MQTT provides a secure and efficient way to monitor environmental conditions, track robot status, and send commands remotely, even over constrained networks. It enables real-time alerting, logging, and analytics, significantly enhancing operational safety, awareness, and decision-making.

SOFTWARE

The Arduino IDE is the primary software used for programming microcontrollers such as Arduino UNO, NodeMCU (ESP8266), and other embedded boards. It provides a simple and user-friendly interface that allows developers to write code, compile it, and upload it directly to the hardware. In the case of a multi-functional military robot, the Arduino IDE is used to program all the logic required to operate various sensors and modules including the DHT11 (temperature and humidity sensor), MQ-7 (gas sensor), IR sensor, buzzer, and ESP8266 for IoT communication. Using pre-built libraries like DHT.h, ESP8266WiFi.h, and PubSubClient.h, the development becomes easier and faster. These libraries help establish Wi-Fi connections, read sensor data, and implement MQTT-based communication for real-time monitoring and control. The IDE supports serial monitoring, which helps in debugging and verifying live sensor values and outputs. Commands can be written to trigger actions such as sending alerts, activating the buzzer, or publishing sensor data to the cloud via MQTT. By using Arduino IDE, developers can build customizable, scalable, and efficient software for robotic systems. It plays a crucial role in integrating the hardware with IoT platforms, enabling remote operation, automated alerts, and data logging. This makes it an essential tool for building intelligent and responsive military robots used in critical applications.

LITERATURE SURVEY

Earlier military robots were limited to single-purpose tasks like bomb disposal or

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surveillance. Traditional systems used RF or manual control, restricting operational range and real-time feedback. Recent research introduced IoT-enabled robotic platforms using ESP8266 for wireless communication. Integration of MQTT protocol enables real-time monitoring and remote control through cloud or mobile apps. Studies show that DHT11 sensors help monitor temperature and humidity in mission-critical zones. MQ-7 gas sensors are used for detecting harmful gases like CO to ensure soldier safety. IR sensors are widely used in intrusion detection and obstacle avoidance systems. Researchers have emphasized the importance of buzzer alerts for immediate threat notifications. Literature highlights the advantages of data logging, which helps in analysis and strategic planning. Current trends focus on multi-sensor, low-cost robotic systems with modular and scalable designs for defense applications.

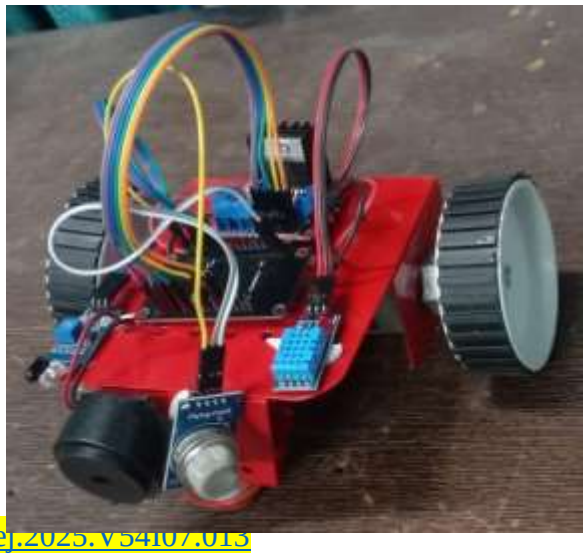
APPLICATIONS

- Border Surveillance
- Intruder Detection
- Gas Leak Detection
- Environmental Monitoring
- Search and Rescue Missions
- Remote Military Base Monitoring
- Combat Zone Navigation
- Early Threat Alert System
- IoT-Based Mission Data Logging
- Smart Surveillance Robots

CONCLUSION

The development of a Multi-Functional Robot for Military Applications using IoT represents a robust and scalable solution for enhancing defense operations in critical environments. By incorporating sensors like DHT11 for environmental monitoring, MQ-7 for toxic gas detection, and IR sensors for obstacle and intrusion detection, the robot is capable of collecting vital real-time data from the field. With the integration of ESP8266 and MQTT protocol, the robot supports remote monitoring and control, enabling operators to manage missions from safe locations with minimal latency. The system's ability to send alerts via buzzer and mobile notifications ensures timely response to potential threats, enhancing situational awareness and reducing risks to personnel. Additionally, features such as data logging, modular hardware design, and low-power operation increase its adaptability and usefulness in diverse military applications like border patrol, search and rescue, and urban surveillance. The use of cost-effective components, open-source software (Arduino IDE), and real-time communication protocols makes the robot accessible for research, training, and deployment. Future enhancements could include camera integration, autonomous navigation using AI, and advanced encryption for secure communication. Overall, this IoT-based military robot is a promising step toward smart, safe, and automated defense systems.

IMPLEMENTATION SCREENSHOT:



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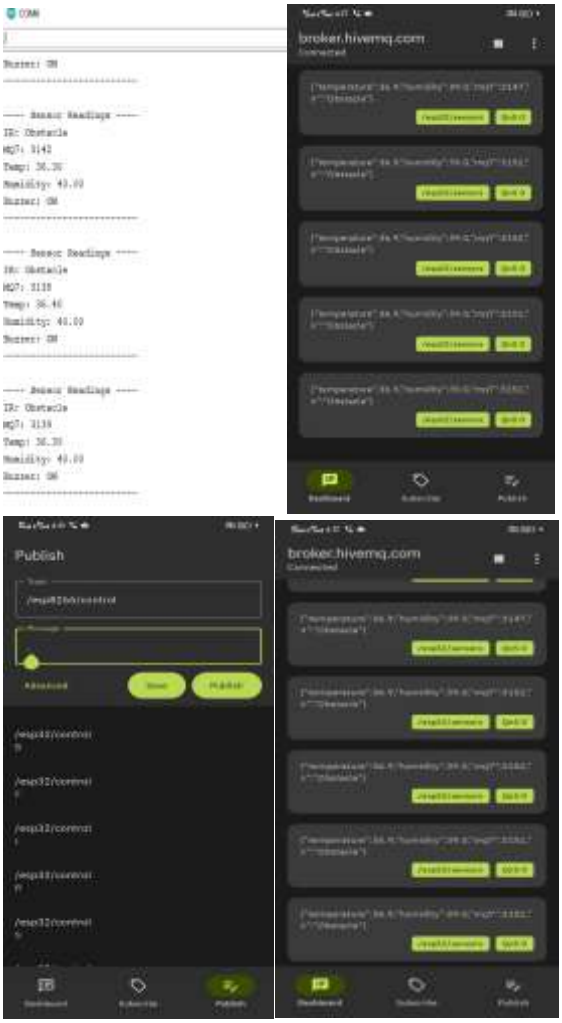

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