

Automatic Bomb/ Metal Detector Robot

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ABSTRACT

An automatic metal detector robot is an intelligent mobile system designed to detect the presence of metallic objects in a given area without direct human intervention. The robot integrates a metal detection sensor with a microcontroller-based control unit and a motorized chassis to enable autonomous movement and real-time detection. When the robot moves over or near a metallic object, the metal detector sensor generates a signal that is processed by the controller. Based on this signal, the robot can stop, alert the user through a buzzer or display, and optionally mark the detected location using indicators such as LEDs or GPS (in advanced versions). The system is particularly useful in applications such as landmine detection, security inspection, industrial waste sorting, underground cable detection, and archaeological exploration, where manual metal detection can be risky, time-consuming, or inefficient. Automation improves safety by reducing human exposure to hazardous environments and enhances detection accuracy by maintaining consistent scanning patterns. The robot can be further enhanced with wireless communication, obstacle avoidance sensors, and data logging features for remote monitoring and analysis. Overall, the automatic metal detector robot provides a cost-effective, reliable, and scalable solution for metal detection tasks in diverse real-world scenarios.

Keywords: - Automatic robot, Metal detector sensor, Microcontroller, Autonomous navigation, Security and Surveillance etc

1. INTRODUCTION

In the present era, security and safety have become critical concerns due to the increasing threats posed by unexploded bombs, landmines, and concealed metallic weapons. Conventional bomb and metal detection methods mainly rely on manual inspection using handheld metal detectors, which exposes security personnel to serious risks and limits operational efficiency. To overcome these challenges, the development of bomb/metal detector robots has gained significant importance. A bomb or metal detector robot is an autonomous or semi-autonomous robotic system designed to detect metallic objects and potential explosive devices while minimizing human involvement in dangerous environments. A bomb/metal detector robot typically integrates a metal detection sensor, a microcontroller or embedded processing unit, and a motor-driven robotic platform. The metal detector sensor works on the principle of electromagnetic induction, where a varying magnetic field is generated and disturbances caused by nearby metallic objects are detected. When the robot encounters a metallic object, the sensor produces a signal that is processed by the controller to trigger alerts such as buzzers, LEDs, LCD messages, or wireless notifications. This immediate feedback allows operators to identify the presence and approximate location of suspicious objects without direct physical contact.

The robotic platform is equipped with DC motors or servo motors controlled through motor driver circuits, enabling smooth navigation across different terrains. In advanced systems, the robot may include obstacle avoidance sensors such as ultrasonic or infrared sensors to ensure safe movement in cluttered or uneven environments. Some designs also incorporate remote control or wireless communication technologies like RF, Bluetooth, or Wi-Fi, allowing operators to control or monitor the robot from a safe distance. This capability is especially crucial in bomb detection scenarios, where maintaining a safe standoff distance can save lives. Bomb/metal detector robots are widely used in defense and military operations for landmine detection, border security, and battlefield surveillance. They also find applications in airports, railway stations, public venues, and industrial sites for detecting hidden weapons or metallic hazards. In humanitarian missions, these robots assist in clearing landmines from post-conflict zones, enabling safer rehabilitation of affected areas. Compared to manual detection methods, robotic systems provide higher coverage, consistent scanning, and reduced operator fatigue. With advancements in robotics, embedded systems, and sensor technology, modern bomb/metal detector robots can be enhanced with GPS for location tracking, cameras for visual inspection, and data logging for analysis and reporting. Integration of artificial intelligence and machine learning can further improve object classification and decision-making capabilities. In summary, the bomb/metal detector robot represents a vital technological

solution that enhances safety, efficiency, and reliability in detecting hazardous metallic objects, making it an indispensable tool in modern security and defense applications.

1.1 OBJECTIVE

- To design and develop an automated robotic system capable of detecting metallic objects and potential explosive devices.
- To minimize human involvement and risk during bomb and metal detection in hazardous environments.
- To provide accurate and reliable detection of hidden or buried metallic objects using metal detector sensors.
- To enable remote or autonomous operation for safe inspection of sensitive and high-risk areas.
- To improve security and surveillance in public places such as airports, railway stations, and borders.
- To enhance efficiency and coverage compared to manual metal detection methods.
- To generate real-time alerts using visual or audio indicators upon metal detection.
- To support applications in defense, military, humanitarian demining, and industrial safety..

2. LITERATURE SURVEY

- **K. Suresh, K. Vidyasagar & Abdul Farooq Basha et al. (2015)** Studied a *multi-directional conductive metal detection robot control* system that enables a mobile robot to detect metal in all eight directions using sensor integration and directional control techniques, enhancing scanning coverage and navigation.
- **Ananya Bhattacharyya et al. (2007)** Presented a *Bluetooth controlled metal detector robot* where a metal detector sensor and Bluetooth interface are used to detect metallic objects, with remote control for movement and detection operations.
- **Mujiarto, Aceng Sambas & Irpan Haerudin et al. (2020)** Developed an *Arduino-based metal detector robot* that uses coil induction to sense metal, with Android smartphone control and LCD display of detected frequencies.
- **Sasanka Pavani Somarouthu et al. (2020)** Designed a *snake robot for metal detection* integrating metal sensors and Bluetooth control, useful in environments difficult for humans to reach, demonstrating flexible navigation for landmine and hazardous detection.
- **Mohammad Adil, Shivam Chandak et al. (2024)** Introduced a *metal detector robot* emphasizing accurate detection of landmines with Arduino UNO control, remote Android operation, and LCD feedback for real-time detection data, improving safety and precision.
- **Anuj Singh, Kamlesh Chandra Purohit, Ritika Jaswal et al. (2023)** Proposed an *IoT-based bomb defusing and surveillance robot* that incorporates metal detection for landmine and bomb detection, along with video transmission and remote monitoring to enhance field security.
- **Abhijith U & Sreeja S et al. (2026)** Presented a *land mine detection robot* using an ESP32 controller with metal detector and IR sensors to enhance sensitivity and autonomous area scanning, highlighting combined sensor systems for safer detection.

3. HARDWARE PARTS OF SYSTEM

NODE MCU ESP8266

Node MCU is an open-source hardware and software platform based on the low-cost ESP8266 System-on-a-Chip developed by Esp8266 Systems. The ESP8266 integrates essential computing components such as a CPU, memory, and built-in Wi-Fi, making Node MCU highly suitable for Internet of Things (IoT) applications. The term Node MCU mainly refers to the open-source firmware, which uses the Lua scripting language and is built on the Esp8266 Non-OS SDK and the project. Due to limited resources, users can customize the firmware by selecting only the required modules. Node MCU also supports the ESP8266 platform. The commonly used Node MCU development board is designed in a dual in-line package (DIP) format, allowing easy breadboard prototyping, and is based on the ESP-12 module with a Tensilica Xtensa LX106 core, widely used in IoT systems.



- **Metal Detector Sensor Module**

This is the core sensing unit of the robot. It operates on the principle of electromagnetic induction to detect the presence of metallic objects beneath or near the surface. When metal is detected, the sensor produces an electrical signal indicating the presence of a conductive object.

- **Firebird V (ATMEGA2560)**



Firebird V includes micro controller, sensors, indicators, ZigBee and LCD. Firebird V supports ATMEGA2560 (AVR) micro controller. ATMEGA2560 is a high performance, low power microchip 8-bit AVR RISC based micro controller consists of 256kb ISP flash memory, 8kb SRAM, 4kb EPROM. All AVR microcontrollers can be programmed using In System Programming (ISP), external programmer or using boot loader. Advantage with the boot loader is that one doesn't need any external hardware to load .hex file on the microcontroller. It also protects robots hardware from possible damage due to static electricity and prevents any accidental changes in the fuse settings of the microcontroller. Fire Bird V Omni Directional Robot is based on Fire Bird V ATMEGA2560 platform. It has three omni directional wheels 120 degrees apart. By changing velocity and direction of the wheels robot can move in any direction without changing its orientation.



- **DC MOTOR**

A DC motor converts electrical energy into mechanical energy through the interaction of magnetic fields and current-carrying conductors, producing torque and speed as output. Its input is electrical current or voltage. The motor consists of two main parts: the armature, which is the rotating component made of wire coils wound around a core and connected to a rotating shaft, and the stator, which is the stationary part containing the field coils. Electrical contact between the stationary and rotating parts is achieved through commutators and brushes, allowing current to flow to the armature and enabling rotation.



- **RELAY**

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and most have double throw (changeover) switch contacts as shown in the diagram

- **MEMS SENSOR**

MEMS (Micro-Electro-Mechanical Systems) are miniaturized devices typically ranging from 1 to 100 micrometers in size, integrating mechanical components, sensors, actuators, and microelectronic chip. These systems are known for their small size, low cost, and high accuracy, making them suitable for a wide range of industrial applications. MEMS sensors detect external physical stimuli such as acceleration and respond through mechanical action, which is then converted into an electrical signal. Accelerometers are commonly used inertial sensors and are primarily classified into piezoresistive types.



While both use internal proof masses that react to acceleration, they differ in how the movement of the proof mass is converted into an electrical signal. Due to their compact design and reliability, MEMS sensors are widely used in applications such as robotics, automotive systems, and motion detection devices.

- **ULTRASONIC SENSOR**

An ultrasonic sensor transmits ultrasonic waves into the air and detects reflected waves from an object. There are many applications for ultrasonic sensors, such as in intrusion alarm systems, automatic door openers and backup sensors for automobiles. Accompanied by the rapid development of information processing technology,

new fields of application, such as factory automation equipment and car electronics, are increasing and should continue to do so.



- **RESISTORS**

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage.



4. WORKING & IMPLEMENTATION

The Bomb/Metal Detector Robot operates as an integrated system combining sensing, control, mobility, and alert mechanisms to detect metallic objects or potential explosive devices while minimizing human exposure to danger. The core of the robot is the metal detector sensor, which operates on the principle of electromagnetic induction. As the robot moves over a surface, the sensor continuously emits a magnetic field; when a metallic object is present, it disturbs this field, generating a voltage signal. This signal is sent to the microcontroller—commonly an Arduino or ESP32—which processes the data in real-time. The microcontroller compares the incoming signal against a pre-defined threshold to determine the presence of metal. When the threshold is exceeded, the system triggers an alert through a buzzer, LEDs, or an optional LCD/OLED display to notify the operator immediately. The robot's mobility system consists of DC motors connected to a motor driver module such as L293D or L298N, which allows the microcontroller to control movement in multiple directions—forward, backward, left, or right.

The robot can operate autonomously along pre-defined paths or be remotely controlled using wireless modules like Bluetooth, RF, or Wi-Fi. Advanced versions incorporate obstacle detection sensors such as ultrasonic or infrared modules to navigate safely around obstacles while scanning the area. For enhanced safety and monitoring, some implementations include a camera module to transmit live video feeds to a remote operator, allowing visual confirmation of suspicious objects without human presence in dangerous zones. The implementation process begins with assembling the hardware on a robotic chassis, where the metal detector sensor is mounted at the front, motors are attached to wheels, and the microcontroller, motor driver, and power supply are securely connected. All components are wired carefully to ensure proper communication and stable power supply. The microcontroller is then programmed to read sensor inputs, control motor movement, and trigger alerts when metal is detected. Calibration of the sensor is performed to ensure accurate detection of different types of metals, and the robot is tested for movement efficiency, sensor sensitivity, and alert response. Once operational, the robot can systematically scan areas such as suspected bomb sites, landmine fields, or industrial zones, detecting metallic objects while keeping operators at a safe distance. Overall, the integration of sensing, control, and mobility makes this robot a reliable, efficient, and safe solution for hazardous metal detection tasks.

5. CONCLUSIONS

The Bomb/Metal Detector Robot provides an effective and safe solution for detecting metallic objects and explosive devices in hazardous environments. By combining a metal detector sensor, microcontroller-based control, and robotic mobility, it reduces human risk, improves detection accuracy, and enhances operational efficiency. With optional features like wireless control, obstacle avoidance, and real-time alerts, this robot proves to be a reliable and practical tool for security, defense, industrial safety, and humanitarian applications such as landmine clearance.

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