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AUTONOMOUS/TELE-OPERATED LANDMINE DETECTION ROBOT

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Abstract. An autonomous/teleoperated land mine detection robot vehicle is an advanced robotic system designed to enhance safety and efficiency in detecting buried landmines in hazardous environments. The primary objective of this system is to minimize human involvement in minefield exploration, thereby reducing the risk of injury or loss of life. The robot is equipped with a combination of sensors such as a metal detector for identifying metallic components of landmines and an ultrasonic sensor for obstacle detection and navigation. It operates in two modes: autonomous mode, where the robot follows a pre-programmed path and makes decisions independently, and teleoperated mode, where it is controlled remotely by an operator using wireless communication technologies like Bluetooth or RF modules. The system is typically built around a microcontroller such as Arduino, which processes sensor data and controls actuators like DC motors through a motor driver. Additional modules such as GPS and GSM can be integrated to provide real-time location tracking and alert notifications when a potential mine is detected. Upon detection, the robot stops, activates visual and audio alerts, and transmits the location information to the operator. This dual-mode operation ensures flexibility in different terrains and operational conditions. Overall, the land mine detection robot offers a cost-effective, reliable, and safer alternative to manual detection methods, with significant applications in military operations, border security, and post-conflict area clearance, while also providing a foundation for future advancements using artificial intelligence and improved sensing technologies.

1. INTRODUCTION

An **autonomous/teleoperated land mine detection robot vehicle** is a modern technological solution developed to address the serious threat posed by landmines in war-affected and border areas. Landmines are explosive devices hidden beneath or on the ground, and they remain active for many years, causing danger to both military personnel and civilians. Traditional methods of detecting landmines are slow, risky, and require human involvement, which can lead to severe injuries or loss of life. To overcome these challenges, robotic systems have been introduced that can safely explore hazardous environments and detect mines without direct human contact.

This robot vehicle is designed using embedded systems and sensors, typically controlled by a microcontroller such as Arduino. It is equipped with a **metal detector sensor** to identify buried metallic objects, and an **ultrasonic sensor** to detect obstacles and assist in navigation. The system can operate in two modes: **autonomous mode**, where the robot moves along a predefined path and performs detection automatically, and **teleoperated mode**, where a human operator controls the robot remotely using wireless communication technologies like Bluetooth or RF modules. This dual functionality provides flexibility and ensures better control in complex terrains.

Furthermore, advanced modules such as GPS and GSM can be integrated to enhance the system's capability by providing real-time location tracking and alert messages when a landmine is detected. The robot can immediately stop its movement, activate a buzzer or LED indicator, and send the detected location to the operator for further action. This system not only increases safety but also improves the speed and efficiency of mine detection operations. Overall, the autonomous/teleoperated land mine detection robot represents an important step toward safer and smarter solutions in defense technology, humanitarian demining, and disaster management.

the system can be enhanced with advanced technologies like GPS modules for real-time location tracking and GSM modules for sending alert messages to control stations when a landmine is detected. Some advanced versions may also include cameras for live video streaming, allowing operators to visually monitor the surroundings from a safe distance.

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The robot is designed to stop immediately upon detecting a potential mine and provide alerts using buzzers, LEDs, or communication systems, thereby preventing accidental triggering of explosives. Moreover, such systems can be adapted to work in rough terrains, forests, deserts, and post-war zones, making them highly versatile.

Overall, the autonomous/teleoperated land mine detection robot vehicle represents a significant advancement in modern engineering and defense technology. It not only improves safety and efficiency but also reduces human risk, operational cost, and time required for mine clearance. With further development, integration of artificial intelligence, machine learning, and advanced sensing technologies, these robots have the potential to become fully autonomous systems capable of accurately distinguishing between harmful landmines and harmless metallic objects, thus contributing greatly to humanitarian efforts and global safety.

2. RELATED WORK

Research in the field of **landmine detection robot vehicles** has evolved significantly over the years, focusing on improving safety, detection accuracy, and operational efficiency. Early studies primarily relied on **manual metal detection techniques**, where human operators used handheld detectors to scan the ground. However, these methods were highly risky and inefficient. To overcome this, researchers introduced robotic systems equipped with controlled metal detectors. For example, a study on a controlled metal detector mounted on a robot highlighted that detection accuracy depends greatly on maintaining a proper distance and orientation between the sensor and the ground, which robots can achieve more precisely than humans.

Later advancements focused on **autonomous and semi-autonomous robotic systems**. Researchers developed robots capable of navigating rough terrains using tracks or wheels while carrying multiple sensors such as metal detectors, cameras, and manipulators. These systems were tested in real-world environments like Afghanistan and Croatia, demonstrating improved mine detection rates and operational safety. In addition, remote-controlled robots using RF or wireless communication were introduced to allow operators to control the robot from a safe distance, reducing human exposure to danger. A solar-powered remotely operated robot was also proposed, which improved energy efficiency and enabled long-duration field operations without frequent recharging.

Recent research has focused on **low-cost and embedded system-based designs**, especially using microcontrollers like Arduino. These systems integrate sensors such as metal detectors, ultrasonic sensors, and PIR sensors to detect mines, avoid obstacles, and mark detected locations. Such prototypes are capable of identifying buried metallic mines and preventing the robot from stepping over them, thereby reducing the risk of accidental detonation . Furthermore, modern systems like the “Defence Pal” robot incorporate multiple sensors and wireless control to enhance detection accuracy and provide real-time monitoring of hazardous environments .

In addition to ground robots, researchers have explored **advanced technologies such as Ground Penetrating Radar (GPR), infrared imaging, and airborne detection systems using drones**. These techniques aim to detect both metallic and non-metallic mines, addressing one of the major limitations of traditional metal detectors . Artificial intelligence and machine learning have also been applied to improve detection performance. For instance, neural network-based vision systems have been developed to classify and identify different types of landmines with high accuracy under varying environmental conditions.

Despite these advancements, challenges such as high false detection rates, difficulty in differentiating between mines and metallic debris, and performance issues in complex terrains still remain. Therefore, ongoing research continues to focus on integrating multi-sensor systems, improving autonomous navigation, and developing intelligent algorithms. Overall, previous work in this domain provides a strong foundation for designing more efficient, accurate, and safer autonomous/teleoperated landmine detection robot vehicles.

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3. SYSTEM COMPONENTS

The hardware assembly is summarised in Table 1.

Table 1. Hardware components of the autonomous/tele-operated landmine detection robot

Component	Function	Description
Arduino uno	Processing & communication	Motor driver/Bluetooth
L298 Motor driver controller	Control the speed &direction of motor	Dual H-Bridge Motor Driver Module
HC-05 Bluetooth Module	Provide wireless Bluetooth communication between devices	Wireless Bluetooth Serial Communication Module
12 V Power Supply	Store and supply electrical energy	Store and supply electrical energy
110 RPM DC Motor	Electrical energy into mechanical rotational motion	High torque low speed DC motor
	Enable smooth movement and support load.	Circular components enabling smooth movement of vehicles.
Gsm 800l/ Gps neo-6m	GPS receives signals from satellites Calculates position coordinates (Latitude & Longitude) Sends data to microcontroller (Arduino)	
Ultrasonic sensor	. The sensor sends ultrasonic sound waves (inaudible to humans) These waves hit an object and bounce back (echo) The sensor measures the time taken for the echo to return	

Arduino uno*:* - The Arduino Uno is a widely used open-source microcontroller board that serves as the main control unit in many electronics and robotics projects, including the land mine detection robot vehicle. It is based on the ATmega328P microcontroller and operates at a voltage of 5V, providing a simple and efficient platform for interfacing with various sensors and modules. In this project, the Arduino Uno acts as the “brain” of the system, receiving input signals from components such as the metal detector and ultrasonic sensor, processing this data according to the programmed instructions, and then controlling outputs like DC motors, buzzer, LED, and communication modules. It also facilitates communication with devices like Bluetooth modules, GPS, and GSM for remote control and location tracking. Programming is done using the Arduino IDE, where code is written in a simplified C/C++ language and uploaded to the board via USB.

L298 Motor Driver controller: - The L298N Motor Driver Module is a dual H-bridge motor driver used to control the speed and direction of DC motors in robotics and embedded systems. It works by receiving control signals from a microcontroller such as Arduino or ESP32. The driver amplifies the low-power signals and supplies sufficient current to the motor. Using input pins and enable pins, it allows forward, reverse, stop, and speed control through PWM signals.
HC-05 Bluetooth Module: - The HC-05 Bluetooth Module is a widely used wireless communication module designed to enable short-range Bluetooth connectivity between electronic devices. It operates using the Bluetooth 2.0+EDR protocol and communicates with microcontrollers through a serial UART interface. The module can work in both master and slave modes, allowing it to either initiate or receive connections from other Bluetooth devices such as smartphones, laptops, or microcontrollers.

110 RPM DC Motor: - The 110 RPM DC motor is a low-speed, high-torque electric motor commonly used in robotics and automation projects. It operates on direct current (DC) power, usually between 6V and 12V. The motor contains gears that reduce speed and increase torque, making it suitable for driving wheels and mechanical systems. When DC

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voltage is applied, current flows through the armature, creating a magnetic field that interacts with the stator, causing the shaft to rotate at approximately 110 revolutions per minute.

Fig.1 model of autonomous/tele-operated landmine detection robot

5. WORKING PRINCIPLE

The working principle of an autonomous/teleoperated land mine detection robot vehicle is based on the integration of sensors, microcontroller processing, and controlled movement to safely detect hidden landmines without human risk. The robot continuously scans the ground while moving and takes action based on sensor inputs.

◆ **System Initialization**

When the robot is powered ON:

- The **microcontroller (Arduino)** initializes all components
- Sensors (metal detector, ultrasonic sensor) start working
- Communication modules (Bluetooth/GSM/GPS) get activated

◆ **Movement of Robot**

- The robot moves using **DC motors** controlled by a motor driver (L298N)
- Movement depends on mode:
  - **Autonomous Mode** → follows programmed path
  - **Teleoperated Mode** → controlled by user (mobile/remote)

◆ **Ground Scanning (Mine Detection)**

- A **metal detector sensor** continuously scans the ground surface
- When metallic content (possible mine) is detected:
  - Sensor sends signal to microcontroller
  - Detection is based on change in electromagnetic field

◆ **Obstacle Detection**

- The **ultrasonic sensor** measures distance from obstacles
- If obstacle is detected:
  - Robot stops or changes direction (in autonomous mode)
  - Prevents collision and ensures safe navigation

◆ **Detection Response**

When a landmine is detected:

- Robot immediately **stops moving**
- **Buzzer and LED** are activated for alert
- Prevents robot from moving over the mine

◆ **Location Tracking & Alert**

- **GPS module** captures the exact location
- **GSM module** sends message to operator
- In teleoperation, user also gets live feedback

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◆ **Remote Control (Teleoperation)**

- Using **Bluetooth (HC-05)** or RF:
  - User sends commands (forward, backward, left, right)
  - Robot follows commands in real-time

◆ **Continuous Operation**

- Robot resumes scanning after detection (if programmed)
- Covers entire area systematically

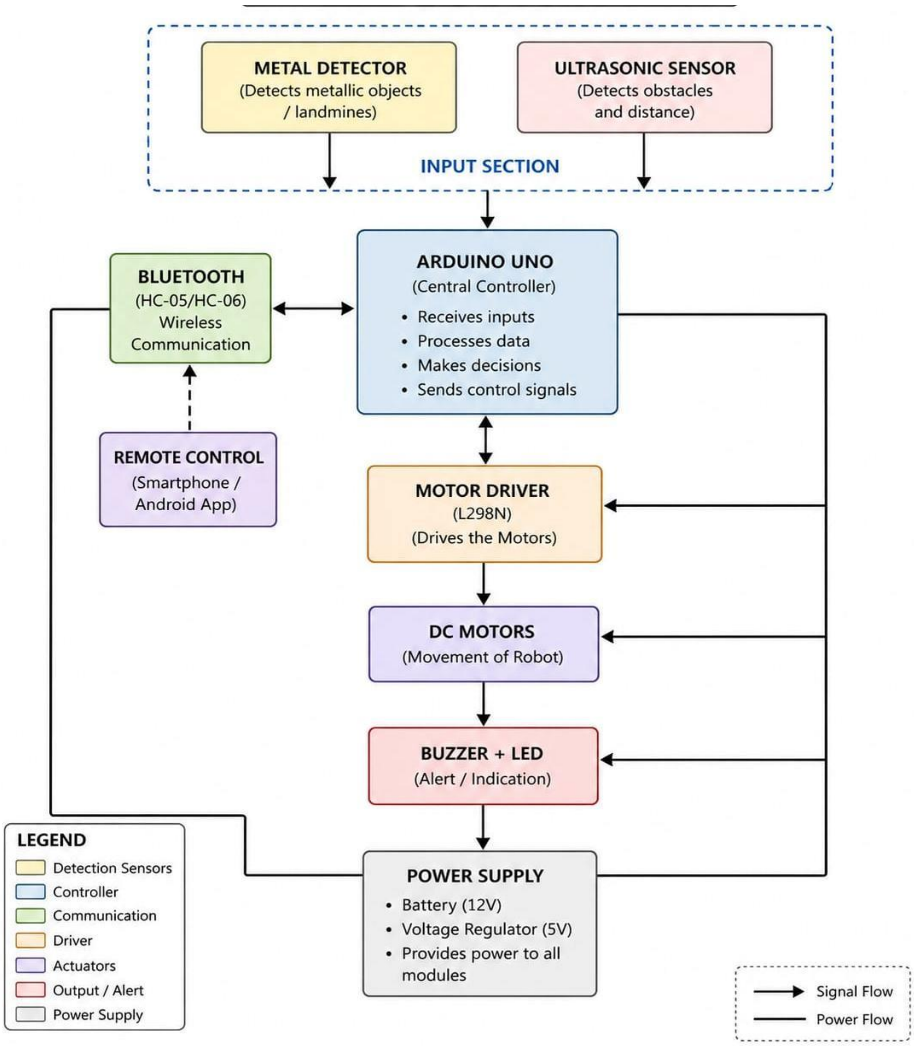

Fig.2 block diagram of autonomous/tele-operated landmine detection robot

6. CODE

```
#include <Servo.h>
#include <AFMotor.h>
#define Echo A0
#define Trig A1
#define motor 10
#define Speed 170
#define spoint 103
char value;
int distance;
int Left;
```


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```
int Right;
int L = 0;
int R = 0;
int L1 = 0;
int R1 = 0;
Servo servo;
AF_DCMotor M1(1);
AF_DCMotor M2(2);
AF_DCMotor M3(3);
AF_DCMotor M4(4);
void setup() {
 Serial.begin(9600);
 pinMode(Trig, OUTPUT);
 pinMode(Echo, INPUT);
 servo.attach(motor);
 M1.setSpeed(Speed);
 M2.setSpeed(Speed);
 M3.setSpeed(Speed);
 M4.setSpeed(Speed);
}
void loop() {
 //Obstacle();
 //Bluetoothcontrol();
 //voicecontrol();
}
void Bluetoothcontrol() {
 if (Serial.available() > 0) {
  value = Serial.read();
  Serial.println(value);
 }
 if (value == 'F') {
  forward();
 } else if (value == 'B') {
  backward();
 } else if (value == 'L') {
  left();
 } else if (value == 'R') {
  right();
 } else if (value == 'S') {
  Stop();
 }
}
void Obstacle() {
 distance = ultrasonic();
 if (distance <= 12) {
  Stop();
  backward();
  delay(100);
  Stop();
  L = leftsee();
  servo.write(spoint);
  delay(800);
  R = rightsee();
  servo.write(spoint);
  if (L < R) {
   right();
   delay(500);
   Stop();
```

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```
      delay(200);
    } else if (L > R) {
      left();
      delay(500);
      Stop();
      delay(200);
    }
  } else {
    forward();
  }
}
void voicecontrol() {
  if (Serial.available() > 0) {
    value = Serial.read();
    Serial.println(value);
    if (value == '^') {
      forward();
    } else if (value == '-') {
      backward();
    } else if (value == '<') {
      L = leftsee();
      servo.write(spoint);
      if (L >= 10 ) {
        left();
        delay(500);
        Stop();
      } else if (L < 10) {
        Stop();
      }
    } else if (value == '>') {
      R = rightsee();
      servo.write(spoint);
      if (R >= 10 ) {
        right();
        delay(500);
        Stop();
      } else if (R < 10) {
        Stop();
      }
    } else if (value == '*') {
      Stop();
    }
  }
}
// Ultrasonic sensor distance reading function
int ultrasonic() {
  digitalWrite(Trig, LOW);
  delayMicroseconds(4);
  digitalWrite(Trig, HIGH);
  delayMicroseconds(10);
  digitalWrite(Trig, LOW);
  long t = pulseIn(Echo, HIGH);
  long cm = t / 29 / 2; //time convert distance
  return cm;
}
void forward() {
  M1.run(FORWARD);
  M2.run(FORWARD);
```

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```
 M3.run(FORWARD);
 M4.run(FORWARD);
}
void backward() {
 M1.run(BACKWARD);
 M2.run(BACKWARD);
 M3.run(BACKWARD);
 M4.run(BACKWARD);
}
void right() {
 M1.run(BACKWARD);
 M2.run(BACKWARD);
 M3.run(FORWARD);
 M4.run(FORWARD);
}
void left() {
 M1.run(FORWARD);
 M2.run(FORWARD);
 M3.run(BACKWARD);
 M4.run(BACKWARD);
}
void Stop() {
 M1.run(RELEASE);
 M2.run(RELEASE);
 M3.run(RELEASE);
 M4.run(RELEASE);
}
int rightsee() {
 servo.write(20);
 delay(800);
 Left = ultrasonic();
 return Left;
}
int leftsee() {
 servo.write(180);
 delay(800);
 Right = ultrasonic();
 return Right;
}
```

7. RESULTS AND ADVANTAGES

Performance Evaluation

The implementation of the **autonomous/teleoperated land mine detection robot vehicle** shows effective performance in detecting buried metallic objects that simulate landmines. During testing, the robot successfully moved across the designated area in both autonomous and teleoperated modes. The **metal detector sensor** was able to identify the presence of metallic objects beneath the ground surface and send signals to the microcontroller. Upon detection, the robot immediately stopped, activated the buzzer and LED indicators, and prevented further movement over the suspected area. The integration of the **ultrasonic sensor** ensured smooth navigation by avoiding obstacles, while communication modules like Bluetooth allowed real-time control and monitoring. In systems equipped with GPS and GSM, the robot was able to transmit the exact location of detected objects, making it highly useful for mapping hazardous zones. Overall, the system demonstrated reliability, safety, and efficiency in detecting potential landmines while minimizing human involvement.

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Start
↓
Initialize System
↓
Select Mode
↓
Move Forward
↓
Scan for Metal
↓
Metal Detected?
├── Yes → Stop → Alert → Send Location
└── No
↓
Obstacle Detected?
├── Yes → Change Direction
└── No → Continue Moving
↓
Repeat
↓
End

Fig.3 Flowchart

KEY ADVANTAGES

The system offers the following principal advantages:

Enhances Human Safety

The biggest advantage of this system is that it completely removes the need for humans to physically enter dangerous minefields. Landmines are highly sensitive and can explode with slight pressure, so using a robot ensures that detection is carried out from a safe distance, protecting lives.

Reduces Risk of Injury and Fatalities

Traditional mine detection methods involve soldiers or workers manually scanning areas, which is extremely risky. This robot minimizes human involvement, thereby significantly reducing injuries and loss of life during detection operations.

Dual Mode Operation (Autonomous + Teleoperated)

The robot can work in both autonomous mode (self-operating) and teleoperated mode (controlled by a human). This flexibility allows it to adapt to different terrains and situations, improving efficiency and control.

Real-Time Detection and Alert System

The system provides instant feedback when a landmine is detected. It activates buzzers, LEDs, and can send alerts via GSM or Bluetooth, ensuring that the operator is immediately informed about the danger.

Accurate and Continuous Monitoring

Sensors like metal detectors continuously scan the ground with better consistency than humans. This improves detection accuracy and ensures no area is missed during operation.

Obstacle Avoidance Capability

With the help of ultrasonic sensors, the robot can detect obstacles and avoid collisions. This allows smooth navigation even in rough or unknown terrains.

Cost-Effective Solution

Compared to advanced military equipment, this system can be built using affordable components like Arduino, basic sensors, and simple motors, making it suitable for educational and low-budget applications.

Location Tracking and Reporting

When integrated with GPS and GSM modules, the robot can send the exact location of detected landmines. This helps in mapping dangerous areas and planning safe removal operations.

Remote Operation

Using Bluetooth, RF, or Wi-Fi, the robot can be controlled from a distance. This ensures that operators remain safe while still having full control over the system.

Expandable and Upgradeable System

The system can be easily enhanced with new technologies like cameras, artificial intelligence, and advanced sensors. This makes it future-ready and adaptable for more complex applications.

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8. APPLICATIONS

Military Operations
The robot is widely used in defense sectors to detect landmines in war zones and conflict areas. It helps soldiers clear minefields safely without risking their lives and supports safe troop movement.

Border Security
It is used along national borders to identify hidden explosives and suspicious objects. This improves surveillance and prevents infiltration or attacks in sensitive areas.

Post-War Area Clearance
After wars, many regions remain contaminated with landmines. This robot helps in humanitarian demining by safely scanning and identifying mines so that they can be removed and the land can be reused.

Disaster Management and Rescue
In disaster-affected areas (like earthquakes or explosions), the robot can be used to explore dangerous zones, detect hazardous objects, and assist rescue teams without putting human lives at risk.**Hazardous Environment Exploration**
The robot can operate in environments that are unsafe for humans, such as chemical plants, radiation zones, or explosive-prone areas, making it useful for industrial safety inspections.

Research and Development
Used in engineering and robotics research to develop better detection systems, autonomous navigation, and sensor integration techniques.

Training and Educational Purposes
Widely used in colleges and universities (especially in electronics, robotics, and defense projects) to teach students about embedded systems, sensors, and automation.

Security and Surveillance
Can be used for monitoring suspicious areas like airports, railway stations, or public places to detect hidden metallic threats and improve security systems.

9. FUTURE SCOPE

The following directions are identified for subsequent development:

Dual Mode Operation
The robot can work in both autonomous mode (self-controlled) and teleoperated mode (remote-controlled), providing flexibility in different environments.
Metal Detection Capability
Equipped with a metal detector sensor to identify buried metallic objects (possible landmines) beneath the ground surface.
Obstacle Avoidance System
Uses ultrasonic sensors to detect obstacles and prevent collisions, ensuring smooth and safe navigation.
Real-Time Alert System
When a mine is detected, the robot immediately activates buzzer and LED indicators to alert the operator.
Wireless Communication
Supports Bluetooth (HC-05), RF, or Wi-Fi modules for remote control and monitoring from a safe distance.

10. CONCLUSION

In conclusion, the autonomous/teleoperated land mine detection robot vehicle is an effective and innovative solution for detecting landmines in hazardous environments while ensuring maximum safety. The system successfully integrates sensors, a microcontroller, and wireless communication technologies to perform detection tasks without direct human involvement. By operating in both autonomous and teleoperated modes, the robot provides flexibility and reliability in different terrains and situations.

The use of a metal detector sensor enables accurate identification of buried metallic objects, while additional components like ultrasonic sensors, GPS, and GSM modules enhance navigation, obstacle avoidance, and real-time alert capabilities.

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This reduces the risk of human injury, improves efficiency, and speeds up the process of mine detection and area clearance.

Although there are some limitations, such as false detection of unwanted metallic objects and dependency on environmental conditions, the overall performance of the system demonstrates its practical usefulness in military operations, border security, and humanitarian demining. With future advancements like artificial intelligence, advanced sensors, and improved automation, this technology has the potential to become even more accurate, reliable, and widely used.

Thus, this project represents a significant step toward safer and smarter solutions in defense and rescue applications, contributing to the protection of human lives and the development of modern robotic systems.

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I am equally grateful to my family for their constant support, motivation, and encouragement, which helped me stay focused and dedicated. Finally, I would like to thank everyone who directly or indirectly contributed to the successful completion of this project.

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📘 **Project & Technical Resources**
- Datasheets of sensors (Metal Detector, Ultrasonic HC-SR04, GPS Neo-6M, GSM SIM800L)
- Arduino IDE documentation and libraries
- Online tutorials and research articles related to robotics and automation