Remote Controlled Landmine Detection Robot

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***Abstract*—** Landmines pose a significant threat in post-war zones, leading to civilian casualties and hindering economic development. Manual detection is risky and time-consuming. This paper presents an IoT-based Land Mine Detection Robot designed to autonomously detect and alert the presence of buried landmines using a metal detector, GPS module, and wireless communication. The robot is equipped with an Arduino-based control system that processes sensor data in real-time and transmits location coordinates of detected mines to a remote-control centre via Wi-Fi or GSM module. The system is low-cost, semi-autonomous, and designed to minimize human risk in hazardous areas. Experimental testing demonstrates accurate mine detection and reliable GPS-based location tracking. Future work includes AI-based path planning and mine classification using ML algorithms.

***Keywords*—** Land Mine Detection, IoT, Metal Detector, GPS, Arduino, Autonomous Robot, GSM Communication.

I. INTRODUCTION

Landmines remain one of the most dangerous remnants of war, posing serious risks to civilians and military personnel in post-conflict zones. Traditional landmine detection methods are not only time-consuming but also highly hazardous for human operators. With advancements in robotics and embedded systems, there is an increasing focus on developing intelligent, automated solutions to reduce human involvement in dangerous operations.This project presents a remote-controlled landmine detection robot integrated with a robotic arm, designed using Arduino as the central microcontroller. The robot is equipped with a metal detector sensor capable of identifying buried metallic landmines and a robotic arm that can be used for marking, manipulating, or cautiously handling suspicious objects. The system is wirelessly controlled using Bluetooth, RF, or Wi-Fi modules, allowing the operator to remain at a safe distance while navigating and managing operations in hazardous areas.

The robotic platform offers high mobility, obstacle navigation, and real-time detection, making it suitable for mine-affected terrains. The integration of the robotic arm adds significant functionality by enabling remote interaction with detected objects, which enhances both safety and versatility. Powered by a rechargeable battery and built on a durable chassis, the robot provides a reliable and low-cost solution for mine detection tasks.By combining sensor technology, wireless control, and robotic manipulation, this project aims to contribute a safer, efficient, and practical alternative to traditional mine detection methods. Landmines, remnants of past wars and conflicts, continue to pose a serious humanitarian and security challenge in many parts of the world. Every year, thousands of people are injured or killed by accidental landmine detonations, many of whom are civilians, including children. The conventional methods used for landmine detection—such as manual probing, sniffer dogs, and trained personnel—are not only slow and costly but also extremely dangerous. As a result, there is an urgent need for the development of safer, more efficient, and cost-effective technological solutions to address this global issue.

In response to this challenge, this project focuses on the development of a remote-controlled landmine detection robot integrated with a robotic arm, built using the Arduino microcontroller platform. Arduino is chosen for its open-source flexibility, ease of programming, and extensive support for interfacing with various sensors and actuators. The core objective of this robot is to detect buried metallic landmines using a metal detector sensor and to allow remote handling or marking of suspected objects using a robotic arm—all while keeping the operator at a safe distance from the hazardous area. The robotic platform consists of a durable, all-terrain chassis equipped with DC geared motors for mobility, which are controlled via a motor driver module interfaced with the Arduino. Wireless communication—achieved through Bluetooth, RF, or Wi-Fi modules—enables real-time remote control of the robot's movements and robotic arm actions. The onboard metal detector continuously scans the ground as the robot moves, and when it detects a metallic object (potentially a landmine), it sends a signal to the Arduino. This, in turn, triggers an alert system using LEDs or buzzers to notify the operator of a possible threat. The unique addition of a robotic arm enhances the robot's functionality beyond basic detection. The arm can be used to mark the location of a suspected mine, move light obstacles, or interact with unknown objects from a safe distance. This helps avoid the need for human intervention in close proximity to danger zones and provides added flexibility in field operations. The arm can be controlled through the same wireless interface, with servo motors ensuring precise movements.This project demonstrates a multidisciplinary approach involving robotics, electronics, wireless communication, and embedded programming. The system is designed to be low-cost, scalable, and easily replicable, making it suitable for deployment in regions with limited resources. Moreover, the modularity of the design allows future upgrades, such as the integration of GPS modules for location tracking, cameras for live video feed, or machine learning algorithms for object classification.

II. LITERATURE SURVEY

The landscape of landmine detection has evolved significantly over the years, driven by the need to address the global threat posed by unexploded landmines. The text includes a compilation of pivotal research and developments in this field, highlighting various methodologies and advancements.

At the forefront of these efforts is the work by Manandhar et al. (2015) on a Multiple-Instance Hidden Markov Model (MIHMM) tailored for Ground Penetrating Radar (GPR)-based landmine detection. This research showcases how advanced statistical models can enhance the accuracy and reliability of detecting buried landmines. MIHMM can process complex data patterns, making it a valuable tool for analyzing GPR signals, which are often challenging due to noise and interference. Further emphasizing autonomous systems, Jaradat (2012) discusses the design of an autonomous navigation robot specifically for landmine detection applications. This innovative approach aims to reduce the risk to human life by deploying robots that can navigate hazardous areas with precision, leveraging advanced sensors and algorithms to identify potential threats. Such robots are crucial in making landmine clearing operations safer and more efficient.

The collaborative efforts of Ghribi et al. (2013), as detailed in their publications, outline the design and implementation of landmine-detection robots. Their work illustrates how interdisciplinary approaches can lead to effective engineering solutions, integrating robotics, engineering, and technology to tackle the menace of landmines. The focus on practical applications in real-world environments highlights the importance of prototypes that can be tested and validated in various terrains. The involvement of prominent institutions, such as the Armada Industrial Automation Institute-CSIC, underscores the collaborative nature of this research landscape. Gonzalez de Santos et al. (2014) explore the use of walking robots, which may improve maneuverability in uneven terrains commonly affected by landmines. This exploration into different robotic platforms indicates the ongoing pursuit of optimizing detection methodologies through diverse mechanization strategies. Ilaria Bottigliero (2014) sheds light on the staggering global statistics related to landmines, revealing that approximately 120 million landmines are deployed worldwide. This grim reality emphasizes the urgency and importance of continued research and development in detection technologies, as well as the humanitarian aspect of ensuring safe environments for affected populations.

Further research, such as that reported by MacDonald et al. (2013), evaluates various alternatives for landmine detection. The technical report offers insights into the effectiveness of different methodologies, advocating for continuous improvement and innovation in detection techniques. Jaradat et al. (2012) reiterate the necessity of autonomous navigation in enhancing detection capabilities, highlighting the significance of integrating advanced algorithms with robotics for improved outcomes. In addition, studies by researchers like Kaur (2016) point to the implementation of multi-algorithm strategies employing GPR, showcasing the advantages of using combined techniques to enhance detection reliability. Finally, the works of Malaviya et al. (2015) emphasize the potential of developing autonomous landmine-detecting and mapping robots that can further simplify the monitoring of mine-infested areas.

In summary, the diverse range of studies and reports reflects a vibrant research community dedicated to advancing landmine detection technologies. The integration of robotics, artificial intelligence, and innovative methodologies points towards a future where landmines can be detected and cleared more effectively, ultimately saving lives and enabling safe reuse of land. The continued evolution of this field is not only a technological endeavor but also a moral imperative to address the critical issue of landmines worldwide.

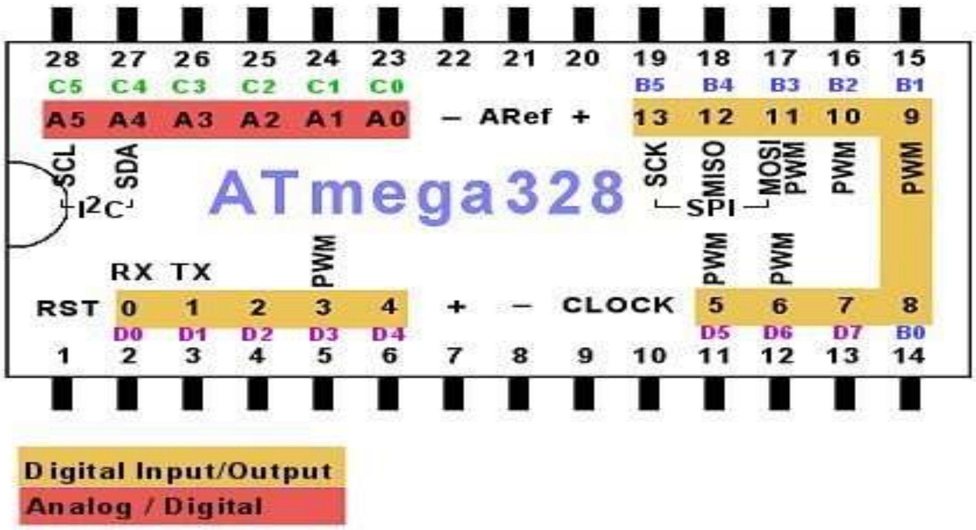
III. EXISTING SYSTEM

The existing systems for remote-controlled landmine detection robots primarily consist of basic robotic platforms integrated with metal detectors and controlled via RF or Bluetooth modules. These systems are typically used in academic or experimental settings and are designed to detect metallic objects buried underground. While they offer a safer alternative to manual demining, they often suffer from high false-positive rates, limited communication range, poor terrain adaptability, and lack advanced features like GPS tracking or real-time video feedback. Additionally, many of these systems cannot distinguish between actual landmines and harmless metal debris, limiting their effectiveness in real-world demining scenarios.

IV. PROPOSED SYSTEM

The robot consists of a rugged four-wheel drive or tracked chassis capable of traversing uneven and dangerous terrains. A metal detector coil is mounted at the front and close to the ground to scan for buried metallic objects. A robotic arm, controlled via servos, is attached to the body and can be used to place markers, lift small debris, or assist in examining suspected landmine locations. The robot is operated remotely using RF or Wi-Fi communication via a custom controller or smartphone interface.

An Arduino Uno or ESP32 microcontroller serves as the brain of the system, handling motor control, sensor data processing, and arm movement. Ultrasonic sensors are used for obstacle detection, while a wireless camera provides a live video feed to assist the operator in navigating and operating the robot and arm. A buzzer and LED system provides



immediate alerts when a metallic object is detected.

Fig No 1: Atmega328 Pin Layout

Key Components

- Arduino Uno / ESP32 – Controls the robot, sensors, and robotic arm.
- Metal Detector – Detects underground metallic landmines.
- Robotic Arm – 4-DOF or 6-DOF arm for manipulation and marking.

- Wireless Camera – Provides real-time video feedback to the user.
- RF/Wi-Fi Module – Enables remote control of the robot and arm.
- Ultrasonic Sensors – Assist in obstacle detection and path planning.
- Motor Driver (L298N) – Controls DC motors and servo motors.
- Power Supply – Rechargeable battery for mobility and operation.

System Functionality

- The user remotely navigates the robot through a wireless interface.
- The metal detector continuously scans for buried metallic objects.
- On detection, the system triggers alerts (buzzer/LED) and transmits location/video to the operator.
- The robotic arm is used to place a marker or move debris near the detection point.
- Optional GPS can be added to log detection locations for mapping.

Advantages

- Enables safe mine detection without risking human life.
- Robotic arm increases flexibility for marking and manipulation tasks.
- Real-time video and sensor feedback enhance operator control.
- Suitable for deployment in diverse terrains and dangerous zones.

In addition to enhancing safety during demining operations, the inclusion of a robotic arm significantly expands the robot's functionality beyond simple detection. The arm can be used to place warning flags or markers at the location of a detected mine, helping demining teams avoid dangerous areas and plan extraction routes more effectively. In some cases, it may also be used to gently remove surface debris such as leaves, rocks, or loose soil that may be covering the mine, allowing for better visibility without direct human contact. The arm's movement is precisely controlled via servos and can be manipulated remotely through a dedicated controller or interface, ensuring accurate and delicate operation even from a safe distance.

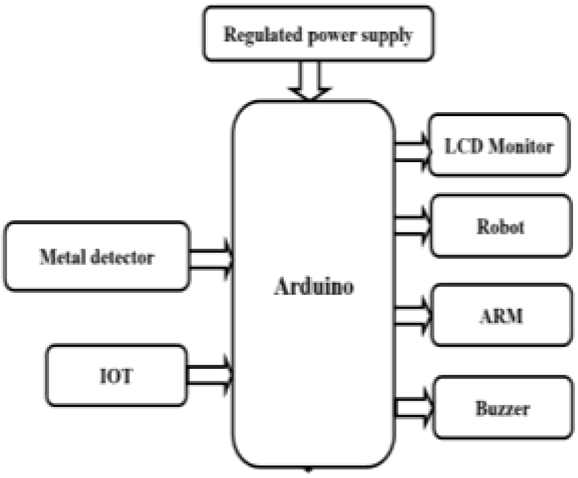


Fig No 2: Block Diagram

To further improve the robot's effectiveness, it can be equipped with a GPS module to record and map mine locations. This geolocation data can be transmitted in real time or stored for later analysis, creating a digital record of suspected minefields. The robot's design also allows for future upgrades, such as integrating AI for object recognition, adding temperature or humidity sensors to assess terrain conditions, or using GPRS modules for long-range communication. Overall, the proposed system offers a modular, scalable, and user-friendly solution to one of the world's most dangerous humanitarian challenges—landmine detection and clearance.

V. RESULTS

Remote-controlled landmine detection robots have significantly transformed the field of explosive ordnance disposal, offering a safer and more efficient alternative to traditional demining methods. These robots are increasingly used in both military and humanitarian missions to detect and neutralize landmines, particularly in conflict-affected regions. Their ability to operate remotely minimizes human risk, making them a crucial asset in modern-day mine clearance operations. From advanced military-grade machines like India's DRDO Daksh to innovative low-cost academic prototypes, these robots have demonstrated promising results in real-world applications and experimental settings alike.

One of the most notable outcomes of using remote-controlled landmine detection robots is the dramatic improvement in personnel safety. In traditionally mined regions, human deminers face life-threatening risks due to the unpredictability of landmine placement and conditions. Robots such as Daksh and mineHAWK are designed to mitigate these dangers. Daksh, developed by India's Defence Research and Development Organisation (DRDO), is equipped with sophisticated sensors, a robotic arm, a portable X-ray device, and a water jet disrupter. It can be remotely controlled from up to 500 meters and is capable of neutralizing explosives in complex urban environments. Similarly, Gridbots' mineHAWK offers a 2-kilometer operational range and can climb inclines up to 45 degrees, allowing it to maneuver over rough terrain. These robots provide a technological advantage in clearing mines with minimal exposure to human operators. Another significant benefit is their high detection accuracy.

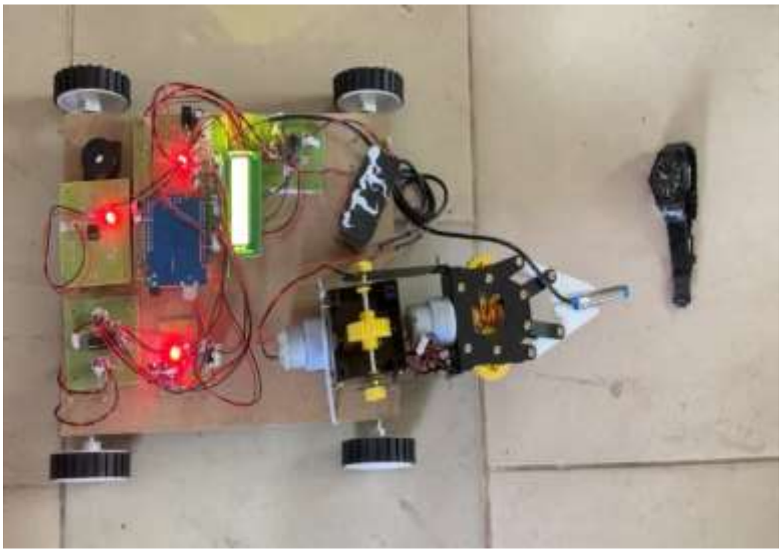


Fig No 3: Hardware Setup

Most landmine detection robots are fitted with metal detectors, ground-penetrating radar (GPR), and sometimes thermal or infrared imaging systems. These components enable the robot to identify various types of landmines, including those with low-metal content that traditional methods might miss. For example, UAV-based detection systems are being developed to complement ground robots by using thermal imaging to detect buried mines from the air. These aerial systems help create heat maps that can highlight anomalies in soil temperature caused by buried objects, further improving detection capabilities in large or inaccessible areas. In academic settings, several prototypes have also shown considerable promise. Researchers have built remote-controlled robots using Arduino platforms, Bluetooth modules, GPS, and gyroscopic sensors. These robots often integrate metal detection systems and use real-time data transmission to map out minefields. A voice and joystick-controlled robot, for instance, demonstrated an ability to detect buried metallic objects with reasonable accuracy while remaining user-friendly and cost-effective. These types of robots could serve as low-budget solutions in areas with limited access to advanced military-grade equipment. However, challenges remain in fully optimizing these systems. Non-metallic mines, which are becoming more common, pose a significant detection challenge, as metal detectors are less effective in identifying them. Additionally, false positives in cluttered or mineral-rich environments can hinder the effectiveness of robotic demining operations. Power constraints, especially in rugged terrains, also limit continuous operation, particularly in lightweight or DIY models.

Despite these limitations, the deployment of remote-controlled landmine detection robots continues to grow. In Ukraine, for example, robots resembling miniature tanks are used daily to detect and clear anti-personnel mines, helping to reduce casualties among demining personnel. As technology continues to evolve, it is likely that these robots will become more autonomous, accurate, and affordable, making them indispensable tools in the global fight against landmine contamination.

VI. CONCLUSION

The development of the remote-controlled landmine detection robot with an integrated robotic arm presents a significant advancement in ensuring human safety during landmine clearance operations. By combining metal detection, robotic mobility, remote communication, and manipulation capabilities, this system offers a reliable and efficient solution for identifying and marking potentially hazardous areas without exposing personnel to danger.

The use of an Arduino microcontroller enables seamless coordination between various modules such as the metal detector, robotic arm, buzzer alert system, and IoT-based communication. This enhances real-time control, feedback, and monitoring, making the system both user-friendly and technically robust. The addition of the robotic arm further improves functionality by enabling the robot to mark or interact with detected sites, thus increasing precision and usability in field operations. Overall, this project demonstrates how embedded systems, robotics, and wireless technology can be effectively integrated to address real-world problems. With further enhancements like GPS tracking, autonomous navigation, and advanced sensor integration, this system has the potential to evolve into a fully autonomous mine detection and mapping solution that can be deployed in real demining missions across the globe.

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